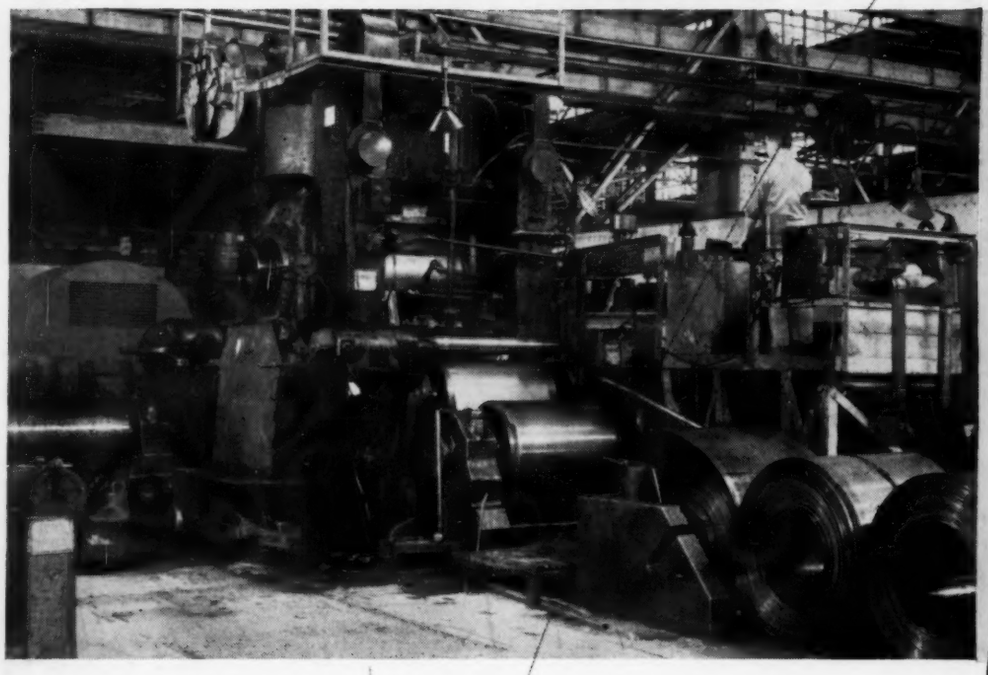
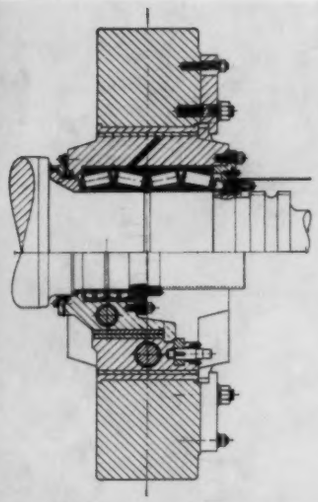
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

SEPTEMBER, 1959





TYPICAL APPLICATION of Timken bearings on work and backup rolls of cold strip mill.

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DETROIT

Inland Steel boosts bearing load capacity 50%—just by switching to Timken® bearings

BY switching to Timken® bearings on the roll necks, Inland Steel obtained a 50% gain in load capacity with no increase in power demand on the 4-high cold reversing mill above. Longer bearing life resulted, too. What's more they gained these advantages without sacrifice of compact design. With previous bearing designs, momentary overloads caused premature failures. And low permissible screw down pressures limited rolling practice.

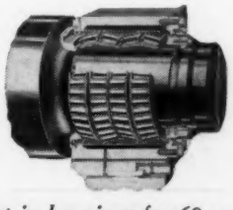
Timken roll neck bearings are used in over 1,000 mill installations around the world to assure minimum cost per ton of steel rolled. That's because: 1) *They roll the load*—virtually eliminate friction. Timken bearings have tapered design to take both radial and thrust loads. 2) *They are precision manufactured*—assuring close control of product gauge. 3) *They minimize maintenance;* Modern Timken roll neck bearings are designed to provide the best combination of bearing capacity, rigidity and roll neck strength for a given mill roll diameter. Bearings and roll necks stand up longer under load. Grease or oil mist lubrication provides further economies. And, 4) *They give longer bearing life.* Mill records show that service life of Timken back-up roll bearings has been obtained in excess of 12,000,000 tons of steel rolled. They're case-carburized to take shock and the full-line contact between rollers and races gives them extra load-carrying capacity.

When you buy or build a mill, make certain you buy the best in bearing performance and engineering service—specify Timken bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

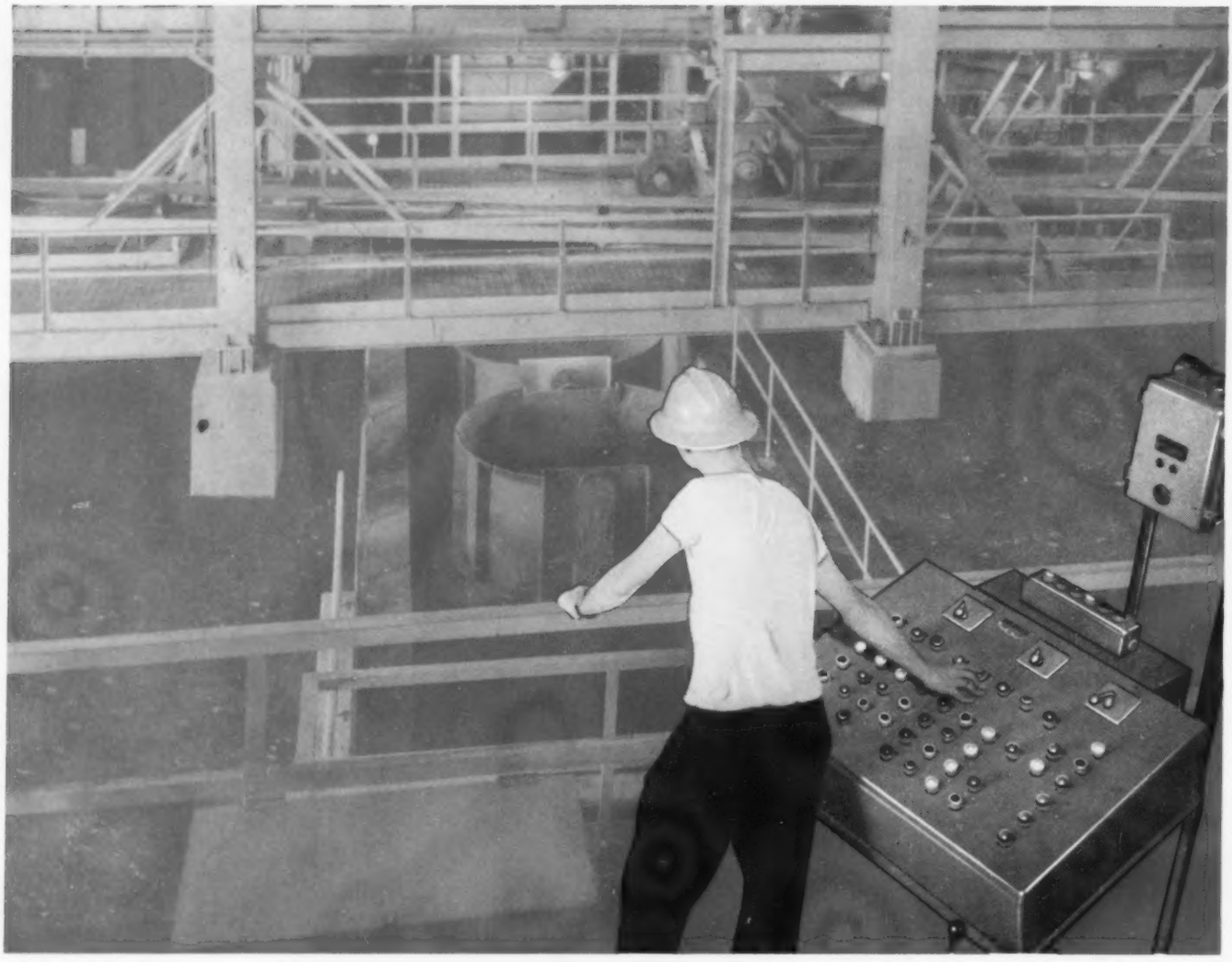
BETTER-NESS rolls on

TIMKEN®

tapered roller bearings



First in bearings for 60 years



ON THE CHARGING LINE AT ACME STEEL

World's largest Cupolas are equipped with Cutler-Hammer Control

To satisfy the 50 tons per hour appetite of Acme Steel's new giant hot blast cupolas, Cutler-Hammer engineered the fully automatic charging control system. Another industry "first", this amazing system directs the synchronized operations of the twin charging buckets between the stock area and cupola top from a single control station. With push-button control the scrap iron, coke, and stone are weighed, logged, and dumped into a waiting charging bucket. The bucket is automatically transferred to the special hooded charging crane which carries the load to the cupola top. Here the motions of the charging crane are integrated with those of the cupola's pressure cap and gates to permit discharging of the bucket onto the burden without losing top pressure.

The development of this *new* and *different* charging system and its control is another typical example of mill engineers, equipment manufacturers, and Cutler-Hammer engineers working together to solve *new* and *different* mill problems. Remember this when you are planning new facilities or modernizing existing machines and processes. Cutler-Hammer's 68 years of Mill Control experience can prove to be a valuable asset to you during the early planning stages. Your inquiry will receive prompt attention without obligation. Dept. S232, Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

Look to Cutler-Hammer Mill Experience . . . as broad as it is long

CUTLER-HAMMER CONTROL C-H

CUTLER·HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

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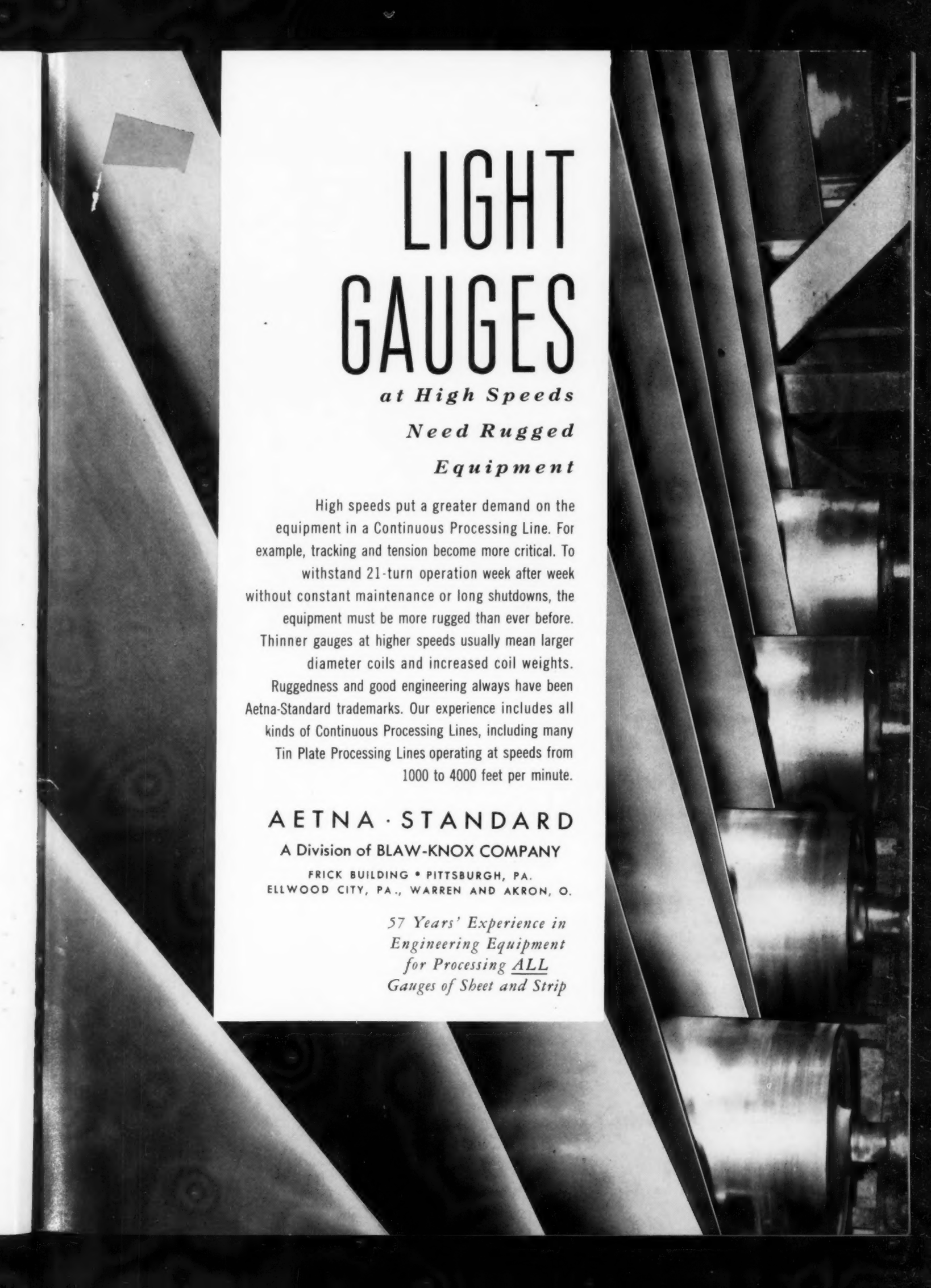

LIGHT GAUGES

at High Speeds

Need Rugged

Equipment

High speeds put a greater demand on the equipment in a Continuous Processing Line. For example, tracking and tension become more critical. To withstand 21-turn operation week after week without constant maintenance or long shutdowns, the equipment must be more rugged than ever before. Thinner gauges at higher speeds usually mean larger diameter coils and increased coil weights. Ruggedness and good engineering always have been Aetna-Standard trademarks. Our experience includes all kinds of Continuous Processing Lines, including many Tin Plate Processing Lines operating at speeds from 1000 to 4000 feet per minute.

AETNA · STANDARD

A Division of BLAW-KNOX COMPANY

FRICK BUILDING • PITTSBURGH, PA.
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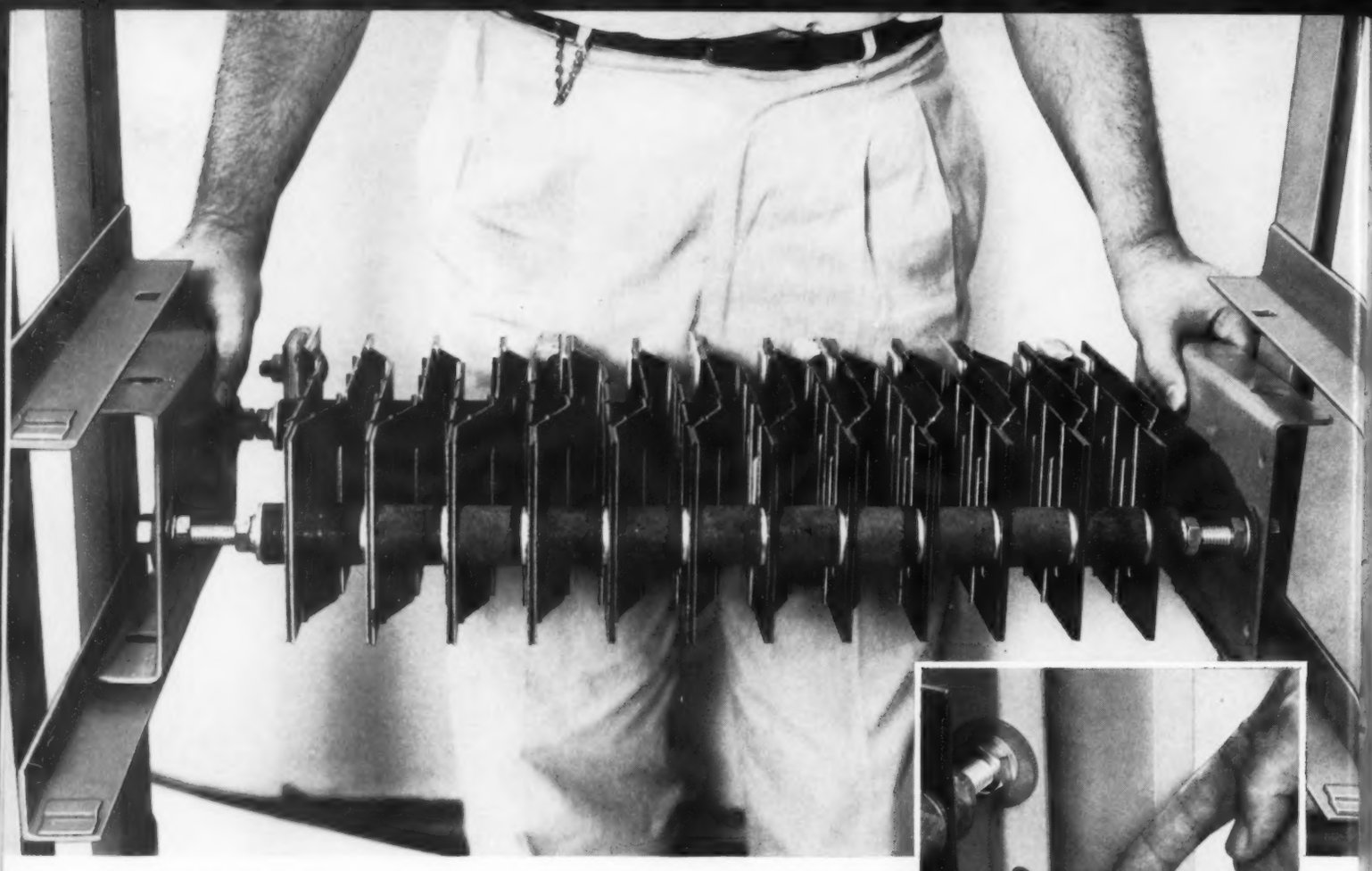
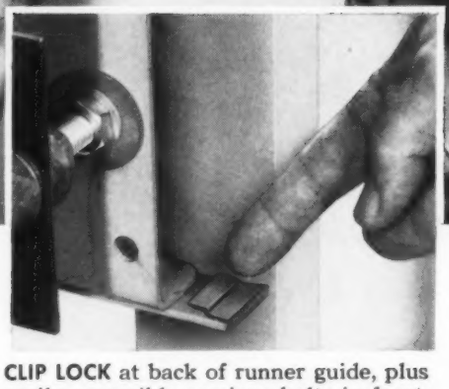
57 Years' Experience in Engineering Equipment for Processing ALL Gauges of Sheet and Strip



DRAW-OUT CONSTRUCTION means fast, easy resistor installation. Runners on the mounting frame guide lightweight resistor boxes into position.



CLIP LOCK at back of runner guide, plus easily accessible carriage bolts in front, hold box securely in position.

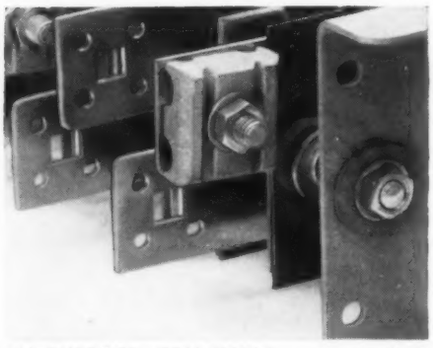
NEW G-E PUNCHED STEEL GRID RESISTORS

Designed for fast, low-cost installation

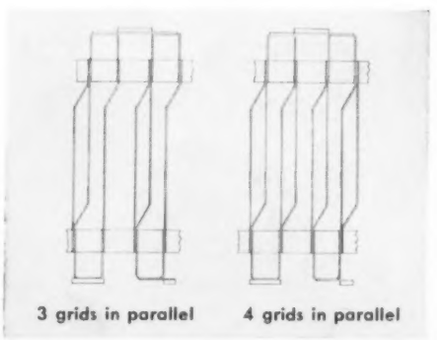
General Electric's new punched steel grid resistors are specifically designed for fast, economical installation. Draw-out construction, clip locks, special grid paralleling and all-purpose terminals all combine to reduce costly installation time.

Reliability and long-life are stressed too. These new high-capacity resistors have corrosion-resistant punched-steel grids, and all associated hardware is zinc-chromate treated for complete corrosion resistance. Double insulation to ground is provided for extra protection on applications where conductive dust and particles are present.

For detailed information, contact your G-E Sales Engineer, or write to Sect. 784-15, General Electric Co., Schenectady, N. Y., for bulletin GEA-6858. Industry Control Department, Roanoke, Va.



ALL-PURPOSE TERMINALS on punched steel grid resistors can be used with many wire sizes—as well as bus.



UNIQUE GRID PARALLELING allows ratings to 740 amps per box. Parallel connections are made at factory.

Progress Is Our Most Important Product

GENERAL ELECTRIC

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Iron and Steel ENGINEER

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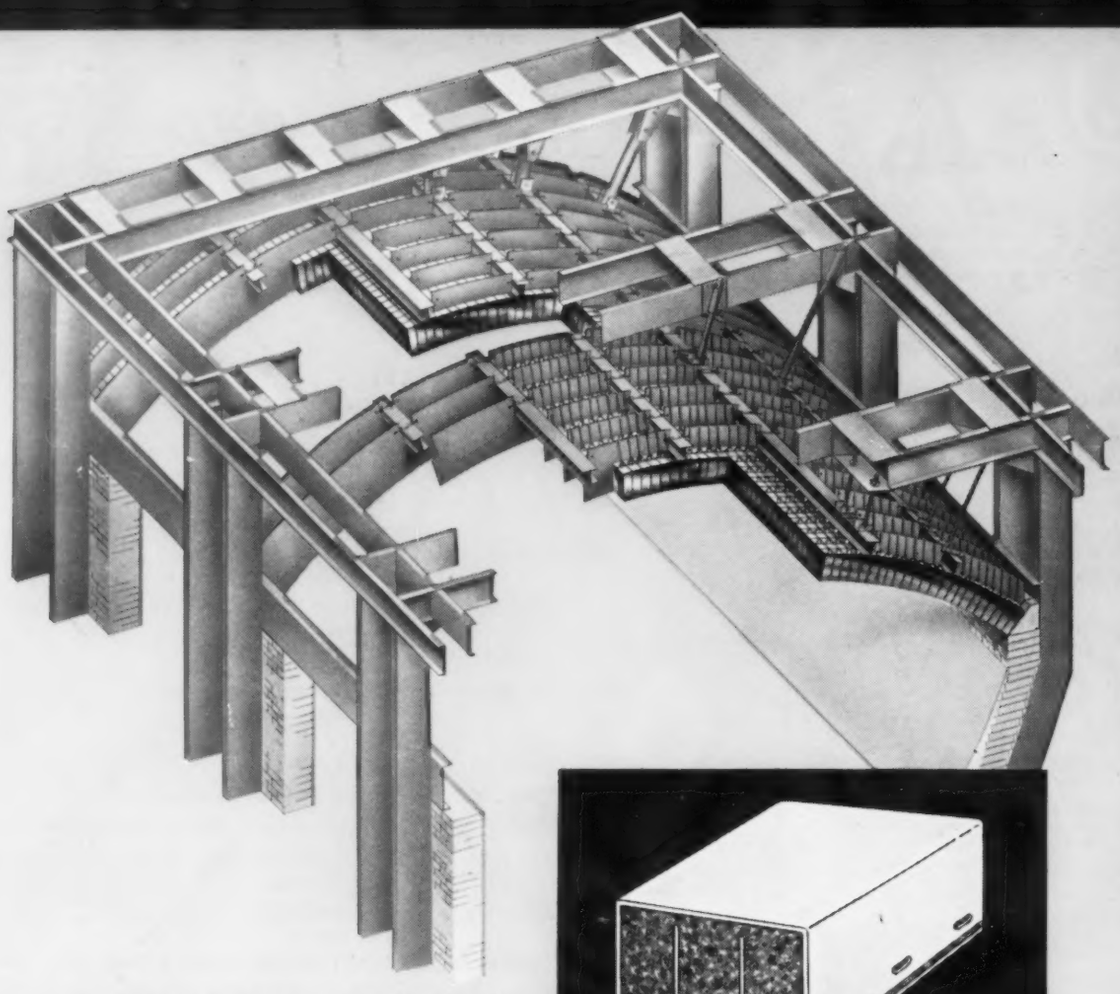
GENERAL REFRACTORIES



Typical construction of open hearth basic roofs using GREFCO *Patented "EE" brick with and without Patented "TAB" suspension.*

GREFCO'S PATENTED "EE" BRICK

GREFCO "ALL-BASIC" FURNACE ROOFS LEAD TO PEAK STEEL PRODUCTION...

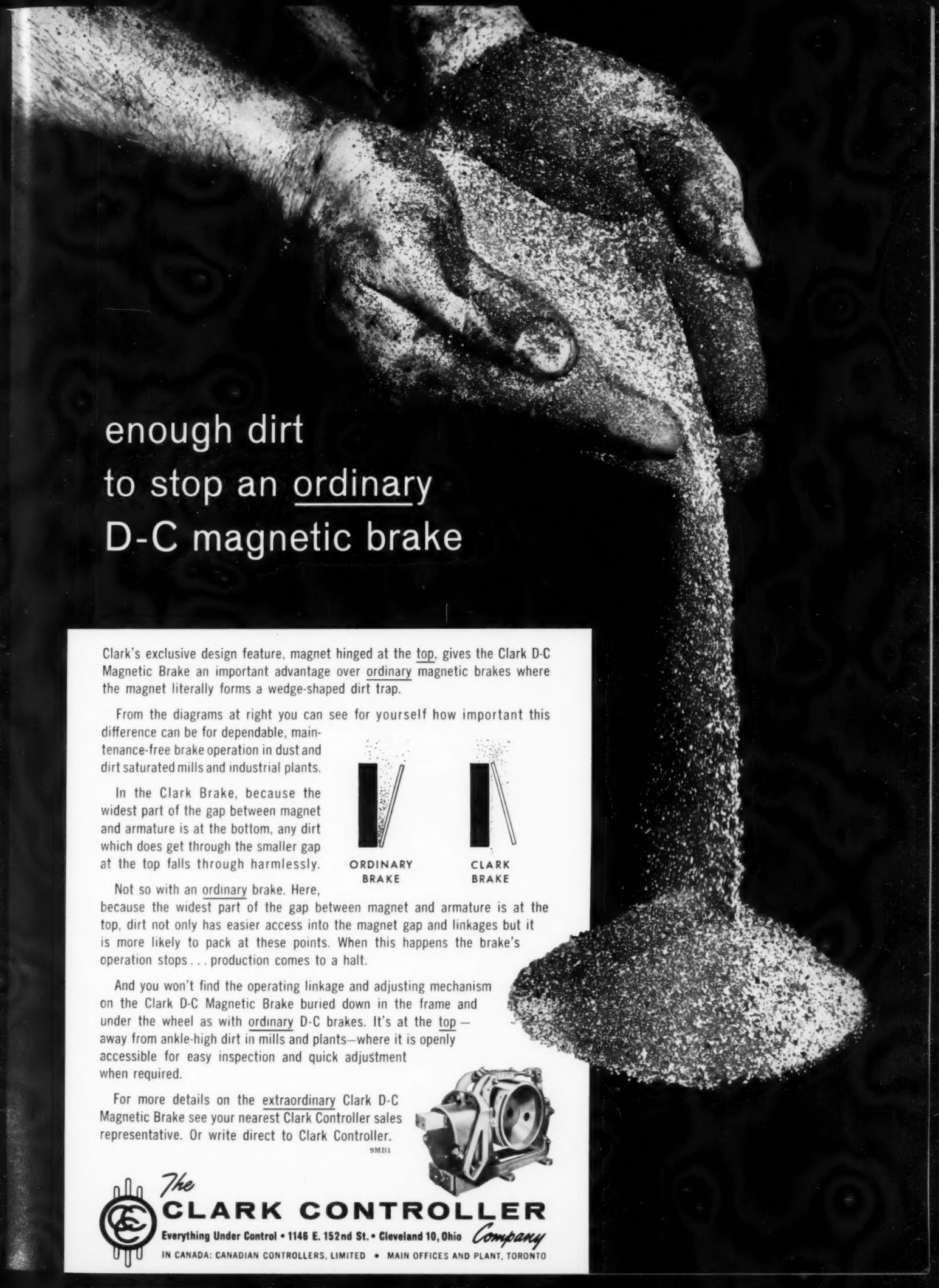
During 1959, many open hearth shops and numerous individual furnaces have repeatedly broken daily, weekly and monthly tonnage records.

This all-out production destroys steel furnace refractories, particularly roofs. But furnace roofs of "EE" basic refractory brick—with steel plates imbedded within them—provide long furnace campaigns despite the high temperatures and other refractory-destroying conditions brought on by high production rates. Basic roofs are becoming standard for open hearth furnaces; over 25% of all American open hearth steel is currently produced under internally plated basic brick.

General Refractories Company, the world's largest supplier of basic refractories, pioneered with steel producers here and abroad in developing the "All-Basic" furnace roof. GREFCO's patented internally plated brick were developed especially for roof service. Over 90% of all American open hearth furnace basic roofs now use brick of this type. They are also gaining rapid acceptance in Europe.

Justifiably proud of this contribution to basic steel-making, GREFCO remains the world's predominant supplier of open hearth basic roof brick. With alert understanding of customer needs, diligent research and aggressive management, GREFCO will continue to lead in basic refractories.

GENERAL REFRACTORIES CO.
PHILADELPHIA 2, PA.



enough dirt to stop an ordinary D-C magnetic brake

Clark's exclusive design feature, magnet hinged at the top, gives the Clark D-C Magnetic Brake an important advantage over ordinary magnetic brakes where the magnet literally forms a wedge-shaped dirt trap.

From the diagrams at right you can see for yourself how important this difference can be for dependable, maintenance-free brake operation in dust and dirt saturated mills and industrial plants.

ORDINARY BRAKE

CLARK BRAKE

In the Clark Brake, because the widest part of the gap between magnet and armature is at the bottom, any dirt which does get through the smaller gap at the top falls through harmlessly.

Not so with an ordinary brake. Here, because the widest part of the gap between magnet and armature is at the top, dirt not only has easier access into the magnet gap and linkages but it is more likely to pack at these points. When this happens the brake's operation stops . . . production comes to a halt.

And you won't find the operating linkage and adjusting mechanism on the Clark D-C Magnetic Brake buried down in the frame and under the wheel as with ordinary D-C brakes. It's at the top — away from ankle-high dirt in mills and plants—where it is openly accessible for easy inspection and quick adjustment when required.

For more details on the extraordinary Clark D-C Magnetic Brake see your nearest Clark Controller sales representative. Or write direct to Clark Controller.

9MB1

The CLARK CONTROLLER Company

Everything Under Control • 1146 E. 152nd St. • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

Results

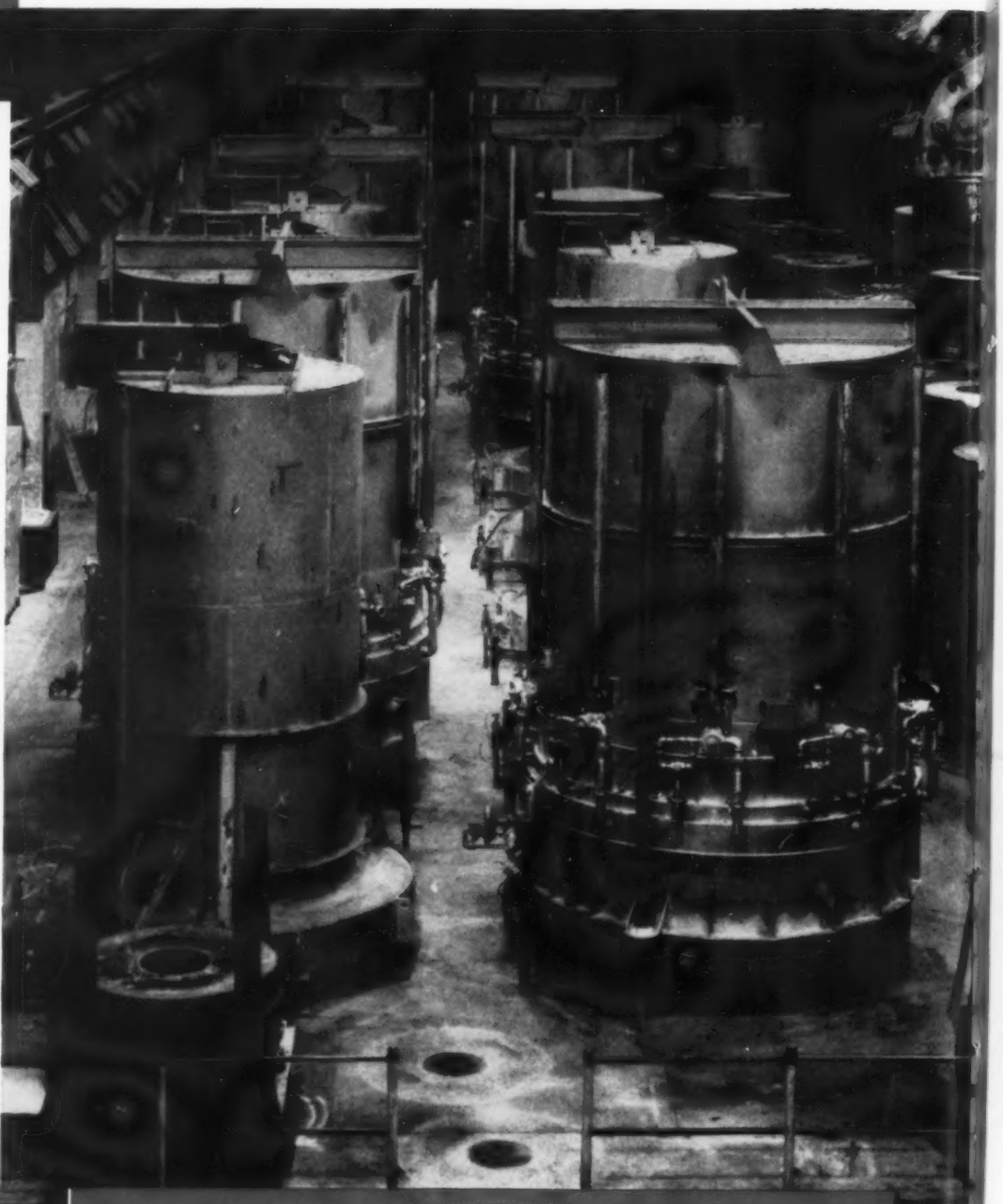
from pilot installation sell Youngstown Sheet and Tube complete 40-furnace Lee Wilson single stack annealing system

Two years ago Youngstown Sheet and Tube installed a pilot single stack annealing operation consisting of six furnaces and 18 bases. Today, after carefully compiling quality-economy comparison records, they have on order a complete Lee Wilson single stack annealing installation of 40 furnaces and 120 bases.

Outstanding results . . . that's what has made the Lee Wilson single stack furnace the most popular method of annealing wherever steel is made.

At Youngstown Sheet and Tube much of the comparison was made on 100 percent drawing quality steel where uniformity of anneal is an absolute necessity.

For uniformity and quality—for speed and flexibility—for economy under any operating condition—nothing beats the Lee Wilson single stack annealing furnace. That's why over 600 of them are in use today all over the world!



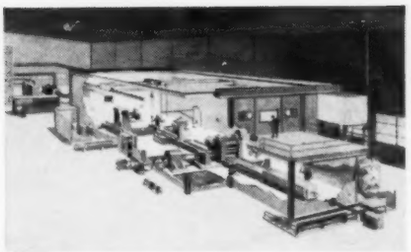
Lee Wilson® ENGINEERING COMPANY, INC.

HIGH PRODUCTION ANNEALING SYSTEMS

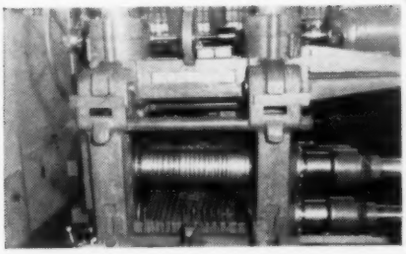
MAKE THE BEST METALS BETTER

ORIGINATORS AND LEADING PRODUCERS OF OPENED COIL AND SINGLE STACK FURNACES

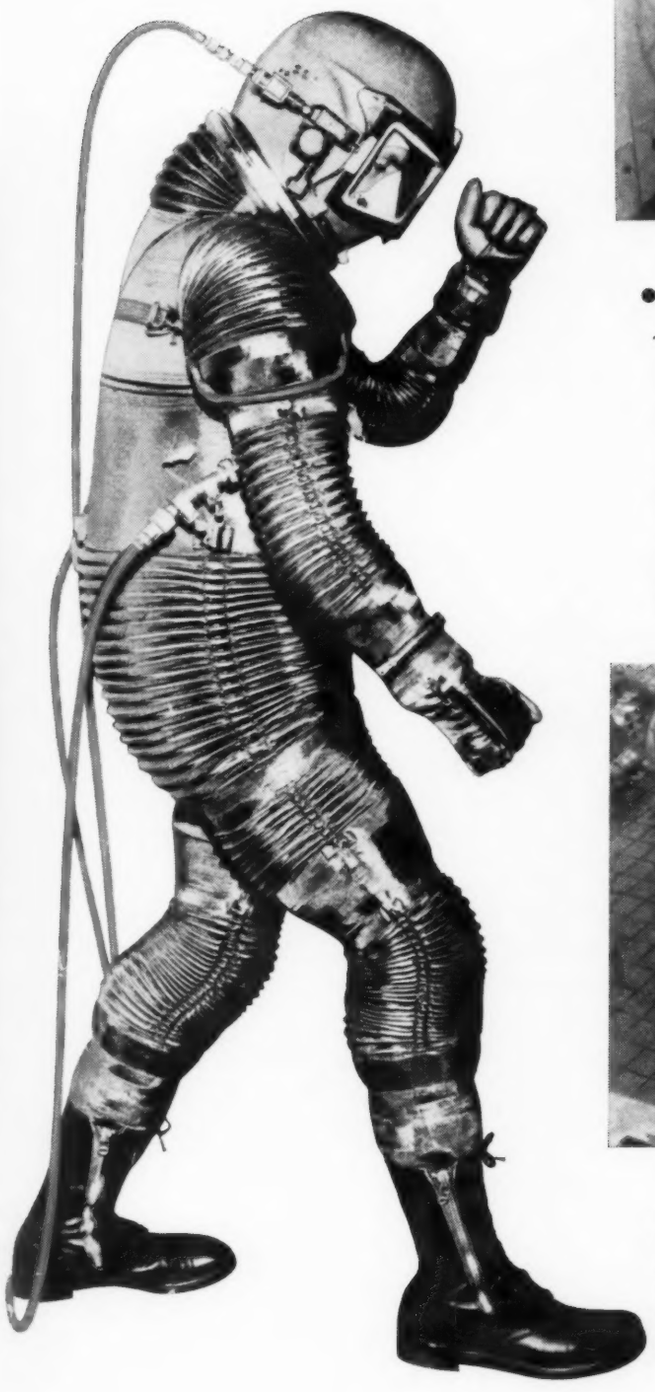
BIRDSBORO *helps close the metalworking gap between* ***today*** *and the* ***future***



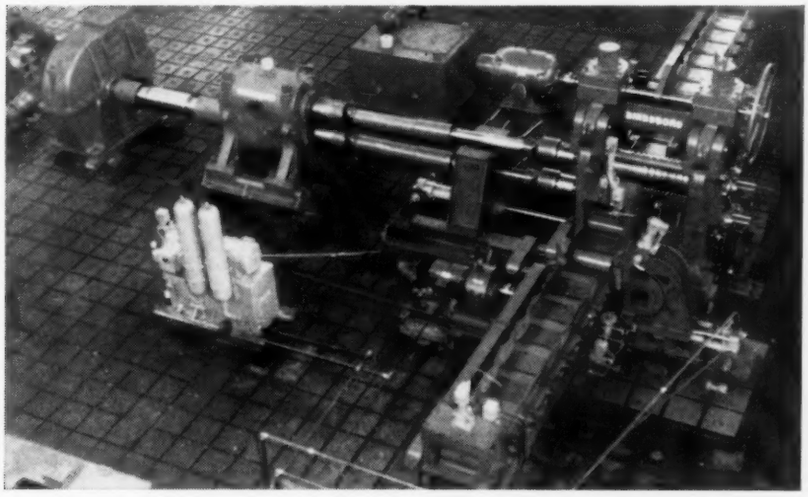
▲ Universal-Cyclops Steel Corporation's IN-FAB facility will fabricate refractory and reactive metals in an inert atmosphere at 3500° to 4000°.



◀ This new BIRDSBORO combination 16″-14″ two-high reversing mill will roll refractory metal flats, squares and rounds.



- The "space-suit" metalworker is not a man of the distant future . . . he starts work in 1959, in the Universal-Cyclops IN-FAB rolling mill facility. Refractory and reactive metals will be produced in an inert atmosphere at 3500° to 4000°. The BIRDSBORO combination 16″-14″ two-high reversing mill used in this facility will roll flats, squares and rounds. It's another "First", a word often associated with Birdsboro. Call Birdsboro in on your next project. There may be a better way to bring the future closer in your operation. *Sales Department, Engineering Department and Mfg. Plant:* Birdsboro, Pa., *District Office:* Pittsburgh, Pa.



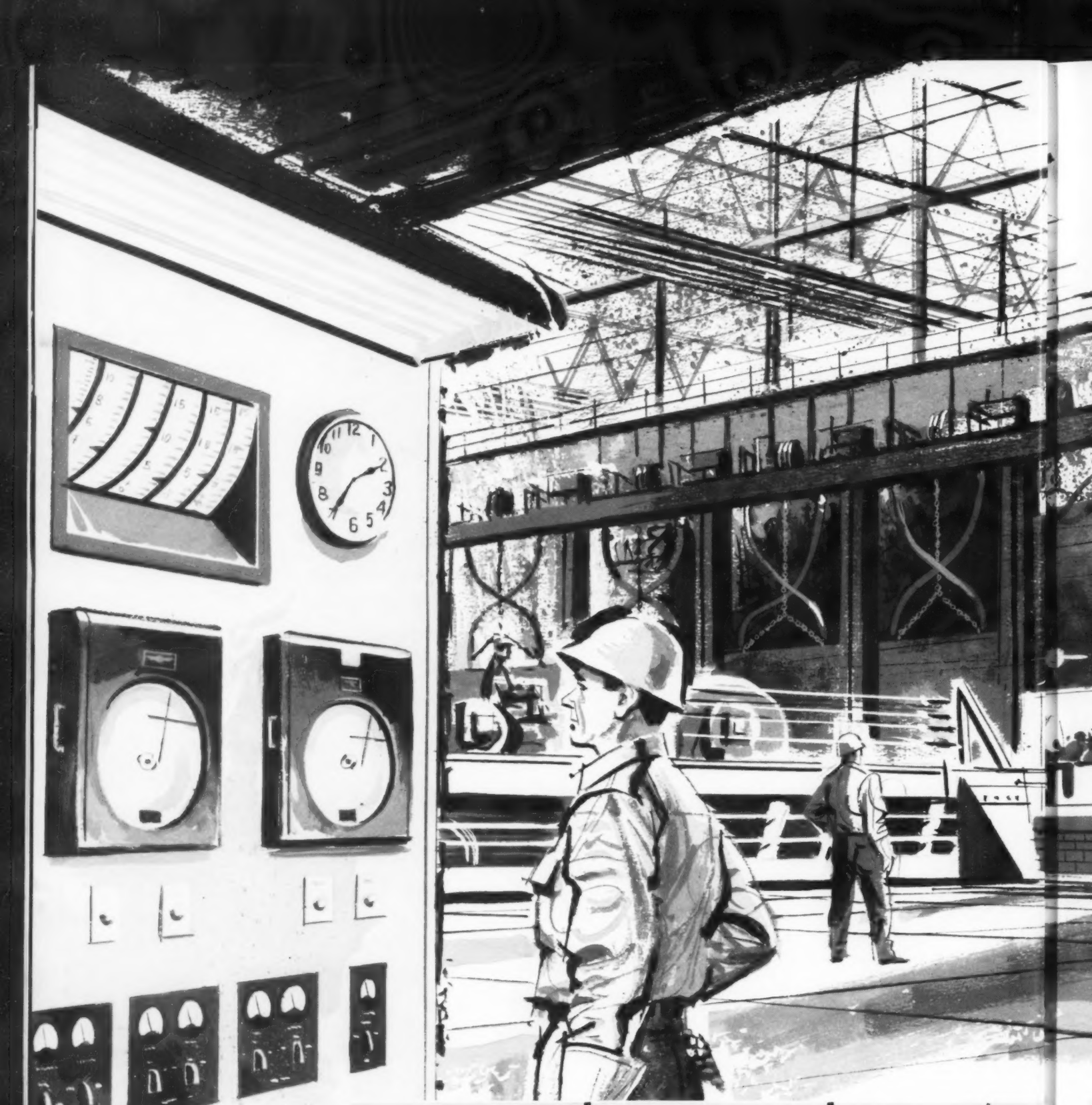
All rolling will be done automatically and controlled by an operator in an outside remote pulpit. The air inside the facility is replaced by argon gas so Universal-Cyclops can fabricate the metals at their best working temperatures. Employees will work in gas-tight suits, entering the plant through an air lock.

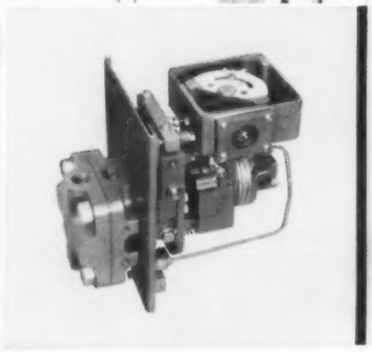
MM-75-59

BIRDSBORO

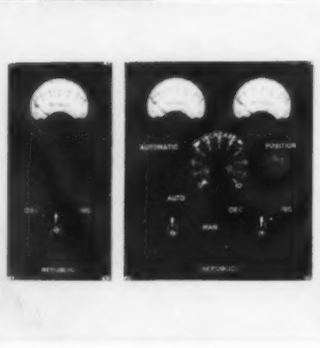
STEEL FOUNDRY AND MACHINE CO.

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • Weldments "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel

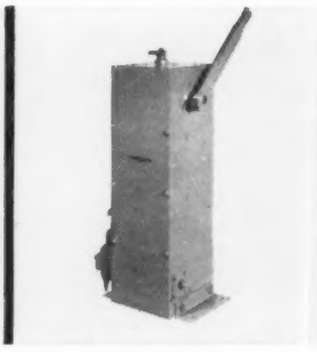




Republic VDP Differential Pressure Transmitter for oxygen and fuel/air flow measurement. VDP Transmitters belong to a new family of pneumatic instruments that use Republic's null-balance-vector principle.



Complete electronic control systems are available for controlling the various functions in an open hearth furnace. Included are transmitters, totalizers, controllers and final drive units.



Republic Final Drive Units operate valves, damper, inlet vanes, etc., in response to air loading pressures or electronic loading signals. They can be controlled automatically or manually, remotely or locally.

From Republic Flow Meters . . .

Complete furnace control system engineering

Whether you are installing a new open-hearth furnace or remodeling an old one, Republic Flow Meters' complete Control Engineering Service gives you three important advantages:

—Because Republic furnishes a complete line of instruments, pneumatic and *electronic* control equipment, *you get* single-source service and responsibility from preliminary system design to start-up.

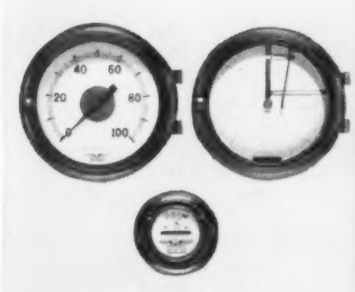
—Because Republic has been making significant contributions to steel mill control systems and equipment for over forty years, *you get* depth of experience plus up-to-the-minute product and system design.

—Because Republic has a nation-wide network of experienced field engineers, valuable installation supervision, final system adjustment and instruction of operating personnel are available to you.

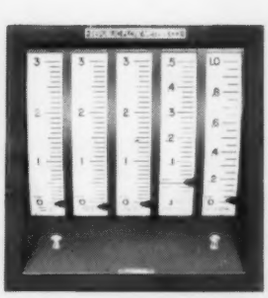
COMPLETE LINE of Republic pneumatic and electronic equipment handles the recording, indicating and controlling functions for open-hearth fuel flow and pressure, air flow, furnace pressure and atomizing steam.

On this page are illustrated a few of the many Republic products designed into your open hearth system. Wherever accuracy of response and precise control are important in the production of steel, Republic products and experienced engineering service are available to meet your needs. For information on Republic's Control Engineering Service, contact the Republic representative nearest you, or write Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Illinois. In Canada: Republic Flow Meters Canada, Ltd., Toronto. Subsidiary of Rockwell Manufacturing Company.

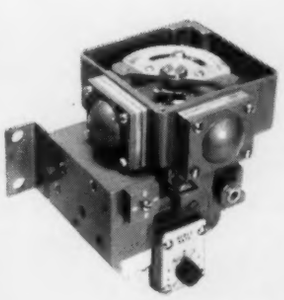
REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL



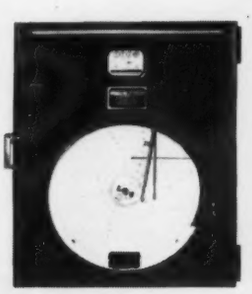
Republic-Pneumatic-electric flow meters for such applications as oxygen, dirty gases and heavy fuel oil measurements have continuous integration and remote electrical transmission.



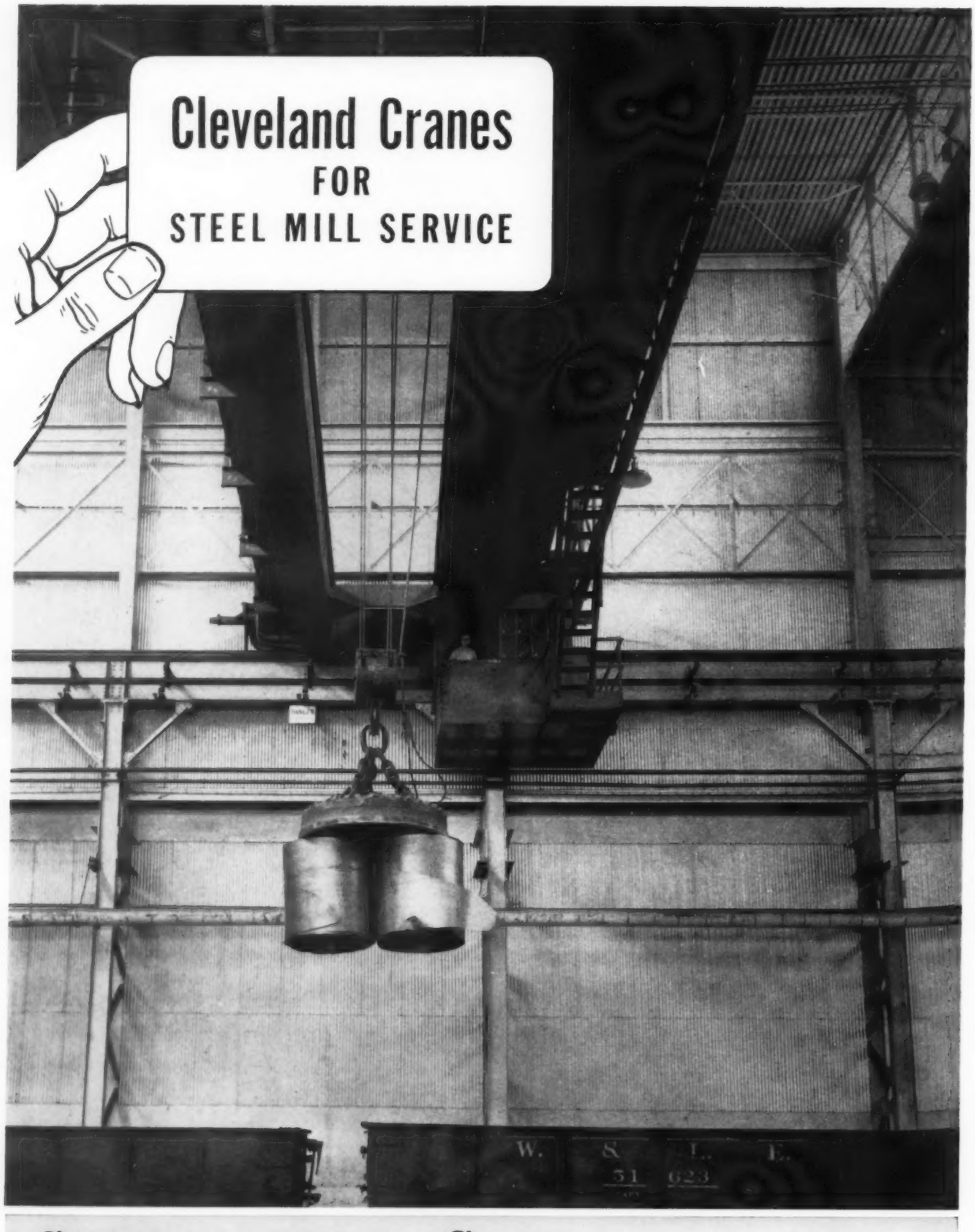
Republic Multi-Point Indicators for drafts, pressures, flows and differentials, have large, easy-to-read scales. These multi-point indicators can be furnished for projected, flush or semi-flush mounting.



Republic VC Pneumatic Controller is an all-purpose null-balance-vector controller for use with any pneumatic transmitter for control of flow, pressure or temperature.



Republic Flow & Pressure Recorders register electrically, pneumatically or mechanically, are simple, compact units of sturdy construction.



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 E. 289th ST.
WICKLIFFE,
OHIO

Crops *and* Shorts

△The special meeting staged by the Detroit district section of AISE at Sault Ste. Marie, Ontario, August 13 and 14 was an enjoyable affair. Approximately 175 men registered. Papers were presented on Algoma Steel's oxygen steel plant and combination bloom-plate mill and on Mannesmann Tube's new tube mill. Inspection trips were held through all of these facilities. David S. Holbrook, Algoma president, gave an excellent after-dinner talk which is printed on page 156 of this issue.

Algoma Steel Corp. and Mannesmann Tube Co. went "all out" to insure the success of AISE's first meeting at the Soo. Thanks are due these companies and their men who set up the arrangements and participated in the program. May there be other Soo meetings—and there probably will be if the 20-odd wives who accompanied their husbands have anything to say.

△The Mitchell report on background statistics bearing on the steel dispute brought no new information and surprised no one. It showed that output per employe man-hour increased by 58 per cent, but it also showed total employment costs per unit of output rising by 142 per cent. It is full of items that brought comfort to both sides in the dispute. Although no conclusions are drawn and no recommendations made, some observers believe the federal government was trying to show the public that both sides had grown fat.

△A letter to the editor of the Pittsburgh Press says:

"If the price of steel and steel wages are blamed for the inflation spiral, why not put a stop to it now by cutting the price of steel, say, 50 cents or $1.00 a ton, leaving the wages where they are?

"I am a steelworker now out of work on account of the strike. I know many fellow workers realize that we gain nothing by a wage increase."

We've heard this idea mentioned a number of times, but always quietly, as though the thought was treasonable or sinful or something. Frankly, we believe it to be the statesman-like solution to the problem, and are disappointed that neither management nor labor made the offer.

△A good, loyal Tarheel says he understands Alaska is considering dividing itself into two equal halves, thereby making Texas only the third largest state.

△Foreign steel producers sent a record volume of steel mill products, totaling 384,787 net tons, into the United States in May, according to the American Iron and Steel Institute. U. S. exports dropped to 165,856 tons.

The first five months of 1959 showed imports of more than 1,500,000 tons, exports of 850,747 tons.

△ A couple of months ago we said we should't complain about growing old because if we weren't doing that we'd be dead. A correspondent says that's true, but the main objection to old age is that there's no future in it.

△ The Value Line Investment Survey sees the steel strike as "a climactic battle in the war between inflation and the stable dollar."

"The nurture of monolithic unions by a benevolent government and an indifferent public has led to the fetish of ever-rising wages, without regard to labor productivity, long range economic well-being or efficient use of manpower."

The Survey sees steel's pledge of no price increase so long as the strike settlement is voluntary as not merely a tactic to win a better labor contract, but rather as "the death knell of inflation as a serious threat to the dollar if steel companies are let alone to resist union wage demands in this critical year."

△ October 4–10 is Fire Prevention Week. Fire losses in the United States in 1958 were $1,305,000,000 in about 2,000,000 fires.

△ Last month we wrote an item for this page as follows: "If Robert E. Lee had had seven baseball teams from the current American league, things might have been different."

Our associates, without exception, read this with blank faces and said, very politely, of course, "Huh?" We meant, naturally, that the Yankees wouldn't have won.

What we'd like to know: are we too, too subtle or are our associates slow on the up-take?

△ You might be surprised to know that some of your tax money goes to publicize and promote a speakers bureau. Recently we received, at home, a letter marked "official business" from the U. S. Department of Health, Education and Welfare. It contained a 4-page leaflet entitled "Are you a program chairman with program problems?" The leaflet invited us to telephone the Federal Business Association for help in securing a speaker from one of the Federal agencies in Pittsburgh. Specifically mentioned were the Federal Mediation and Conciliation Service, The Social Security Administration, The U. S. Army Corps of Engineers, the National Labor Relations Board, the U. S. Department of Commerce Weather Bureau, The Federal Bureau of Mines, the Veterans Administration and the Federal Housing Administration.

△ If you're inclined toward statistics, pause and reflect. Upward of 80 per cent of those who go insane are coffee, tea or beer drinkers—and at least 98 per cent of those who commit suicide sleep indoors.

△ Steel's payroll for the first half of the year is estimated at $2,337,169,000. For June, the payroll for the entire industry is placed at $413,541,000, with employment at 670,400.

△ One of our neighbors says the best insurance against automobile accidents is a Sunday nap.

Behind every EC&M controlled installation...

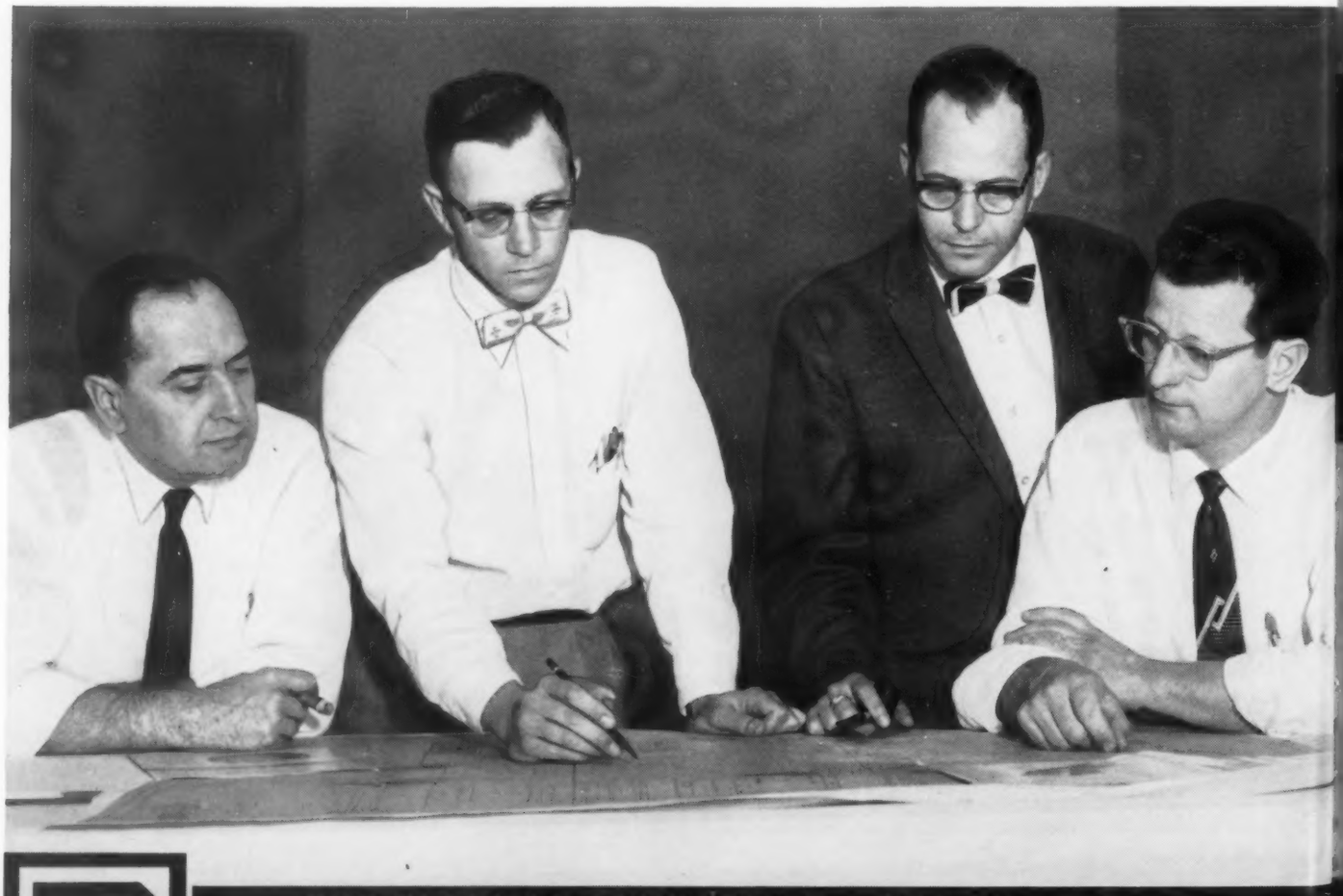
...an EC&M engineering team coordinated their knowledge and experience to design the control system best suited for that particular installation.

EC&M's engineering team studies every facet of an installation...nothing is taken for granted. Then, and only then, is a control system designed.

Advance planning of this type has two important advantages. First, the "tune-up" time of the installation is practically eliminated. Secondly, future maintenance is substantially reduced.

No matter what your requirements may be ...adjustable voltage or constant potential, an ore bridge or an automatic rolling mill control system...EC&M engineering counsel is available to you without obligation.

It will pay you to call EC&M into consultation early, when planning your next installation.

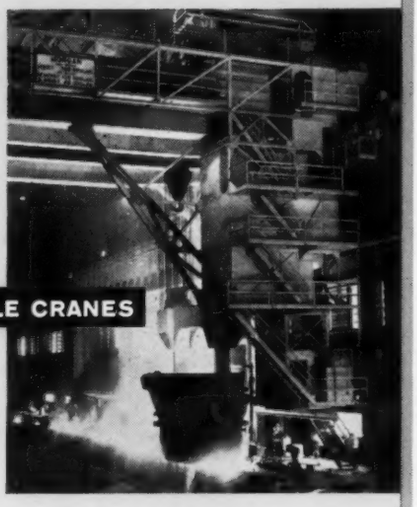


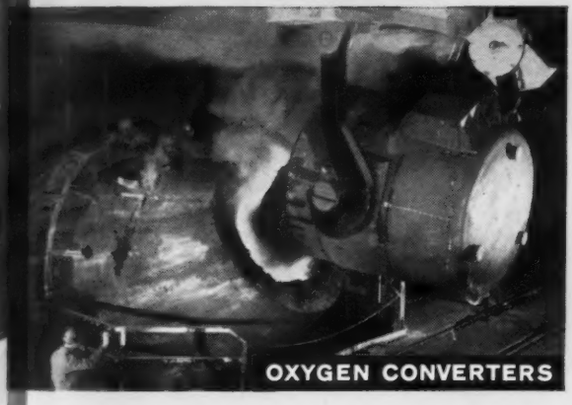
THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

Installations Equipped with an EC&M Control System

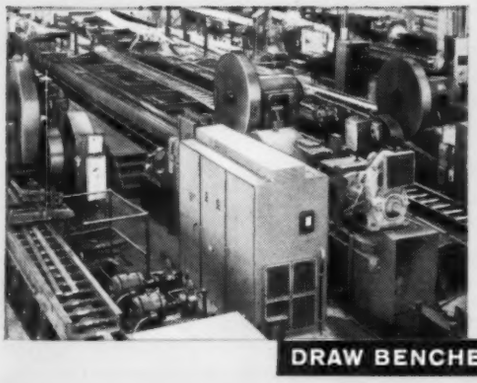
OVERHEAD CRANES

ROLLING MILLS


LADLE CRANES


OXYGEN CONVERTERS

ORE UNLOADERS


DRAW BENCHES

There's an EC&M Control System to fit every application or installation

Material Handling
- Cranes
- Ore Bridges
- Unloaders
- Conveyors
- Car Dumpers
- Aerial Tramways
- Hoists:
  - Skip
  - Mine
  - Slope

Rolling Mills
- Blooming
- Slabbing
- Plate
- Rail
- Beam
- Billet
- Bar
- Rod Merchant

Steel Mill Machinery
- Ingot Buggies
- Screwdowns
- Edgers
- Feed Rolls
- Sideguards
- Manipulators
- Table Rolls
- Transfers
- Coilers
- Oxygen Vessels

Steel Mill Accessories
- Planers
- Lathes
- Boring
- Milling Machines
- Presses
- Scalpers

Processing Lines
- Slitting
- Leveling
- Welding
- Shearing
- Cleaning
- Scrubbing
- Temper Pass
- Reducing Mills
- Wire Drawing
- Draw Benches
- Tube Mills

3522

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We are authorized distributors for all the many lines of bearings and bearing accessories we sell — Bearings, Inc., with the manufacturer, guarantees every bearing we deliver! Avoid surplus or shelf-worn bearings — Get the bearings incorporating the latest design and metallurgical improvements — in the makers' original sealed boxes — from Bearings, Inc. You can then be certain you're getting the longest bearing life for your money.

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VIRGINIA: Richmond

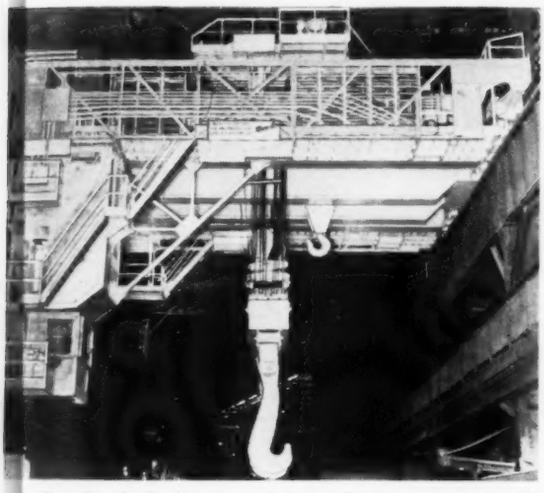
SC Crane speeds outdoor storage. This type of heavy industrial crane is custom built of standardized components. Capacities range from 5 to 40 tons; spans to 120 feet. 3 or 4 motor. Floor or cage operated.

SB Crane on the job in a steel warehouse. This class of standardized crane is built in capacities from 5 to 40 tons; spans to 100 feet. Many built-in "plus values" insure top performance and low operating costs in the severest service.

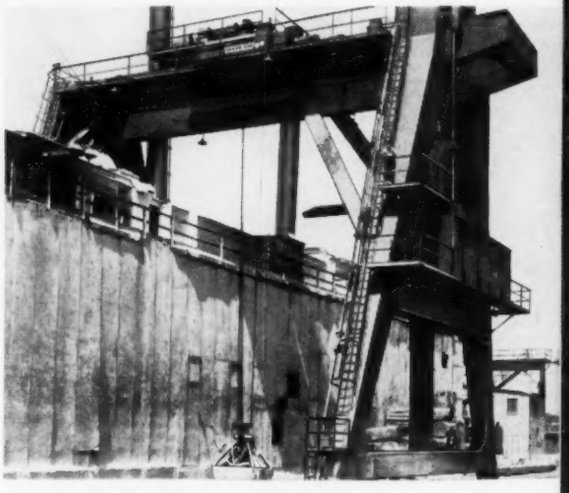
PROOF

of Shaw-Box Crane quality and reliable performance is evidenced by more than 70 years of rapidly growing acceptance from all kinds of industries.

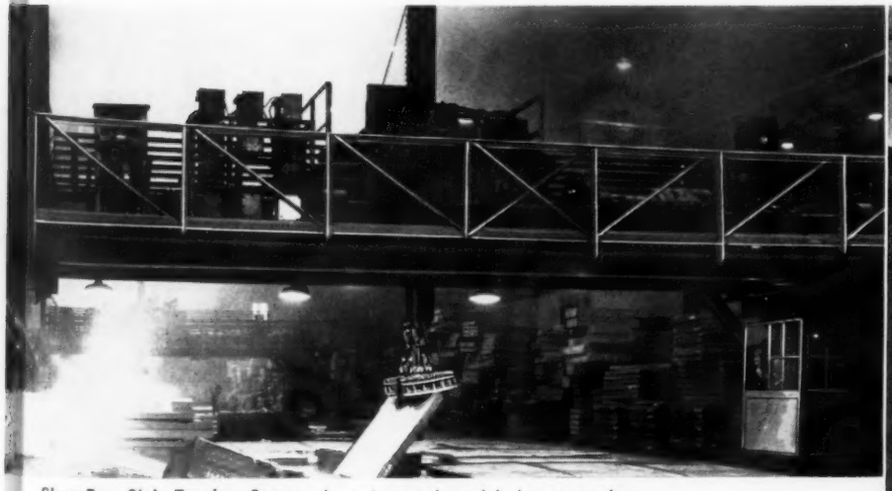
We build all types of cranes to AISE specs or to meet individual standards of structural durability and operational efficiency and economy. Your inquiry is invited.



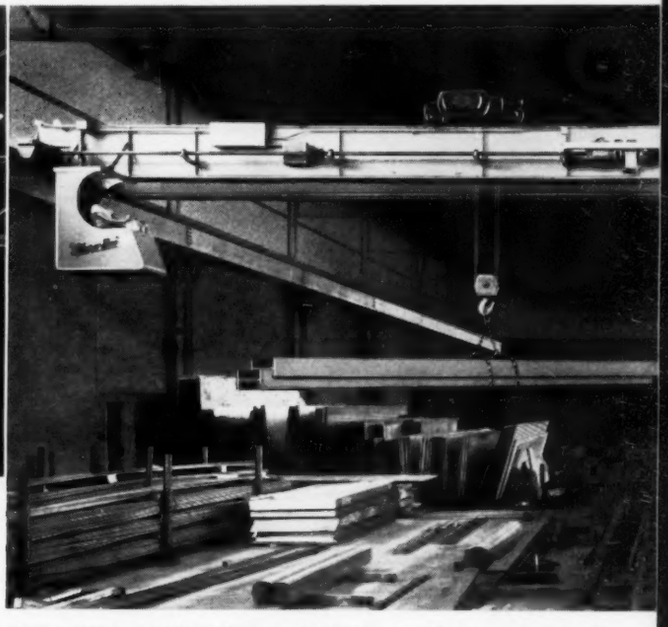
Shaw-Box Ladle Crane. A 4-girder, 9-motor crane with 54 foot span. 90-ton ladle holds 200 tons of molten steel. 75-ton auxiliary trolley handles lighter loads.



Shaw-Box Bucket Magnet Gantry Crane. Our gantries are serving the steel industry to handle plate, slabs, and scrap. We build them for other industries as well, in any desired capacity.



Shaw-Box Slab Turning Cranes do a tremendous job in conserving manpower and reducing costs around the clock. Rigid, non-whipping construction is combined with the utmost resistance to impacts.



Series "D" Load Lifter Cranes. Capacities to 20 tons, spans to 80 feet. Designed for average industrial service. Components are so highly standardized, you can buy your crane from a catalog.

Soaking Pit Cover Carriages are not only made by Shaw-Box, but we also produce the reliable spring drive cable reels that supply current to the carriages. These reels are also widely used on magnet equipped cranes.

ELECTRIC OVERHEAD E.O.C.I. MEMBER CRANE INSTITUTE

59K-1-A

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OVERHEAD CRANES FOR ALL INDUSTRY

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Operator reads Speedomax H chart record

Hot ingot is pulled at Inland

New Trend in Soaking Pit Practice

Accelerated heating of Inland Steel's biggest ingots

Fast heating of giant 20-ton ingots, close temperature control and excellent scale deposition are some of the advantages that Inland Steel is getting from 6 batteries of 18 new Salem-Brosius soaking pits at Indiana Harbor Works.

These advantages are, in part, gained by new accelerated heating systems that feature the Speedomax® Type H temperature controller.

When cold ingots are charged, the pit operator sets a predetermined accelerated heating program by means of a timer on his central control panel. During the period of fast heating, extra fuel is supplied to the pits, driving pit temperature to an accelerated control point. This higher point is determined by metallurgical conditions and may be reset as conditions demand. As the ingot soaks up this extra heat, and the fast-heating period is completed, fuel is cut back and Speedomax H returns the pits to normal control temperature for the remainder of the soak period.

Because of this efficient control system, heat-up time is cut and the production of ingots is increased, assuring that the new rolling mills can operate at maximum output.

Because of their reliability, L&N temperature control instruments are specified by a majority of soaking pit users and manufacturers. So, when you modernize—or build soaking pits—ask your L&N Field Engineer to show you what L&N temperature controls . . . and our equally dependable combustion controls . . . can do for you. Or write to 4942 Stenton Avenue, Phila. 44, Pa.

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TAYCOR, a corundum-base refractory containing 89% high purity alumina, has exceptional resistance to abrasion and attack by iron oxide. Outstanding results have been obtained by TAYCOR when used in the hearths of furnaces heating rails and billets.

An Illinois manufacturer operating the hot mill furnace shown in the photo below, obtained six months' life on chrome-magnesite hearths. A TAYCOR brick hearth has extended this to 12 months.

Contact the Taylor field engineer in your district for recommendations on applications for TAYCOR refractories in your furnaces.

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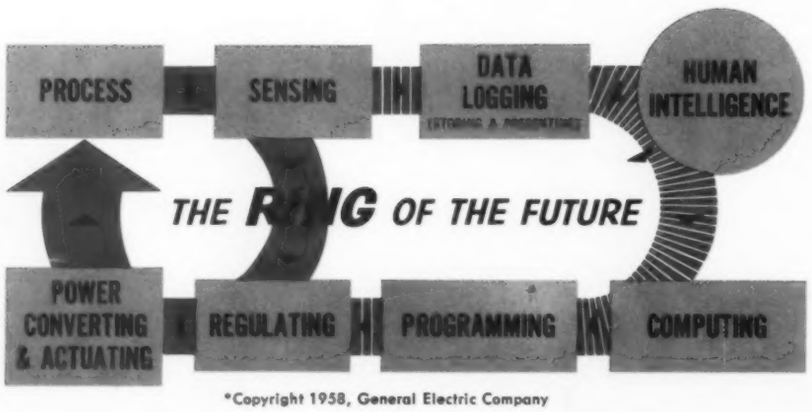

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. . . General Electric's approach to automation, helps you blend the products of today into the systems of tomorrow . . . provides a logical, step-by-step approach to modernization through automation. Start your program now. Call your General Electric Apparatus Sales Office for complete information about the "Ring of the Future" and how it can be applied to:

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For a 13" x 29" lithograph copy of this painting suitable for framing, write on your letterhead to address below.

CAN HELP YOU MODERNIZE FOR PROFITS

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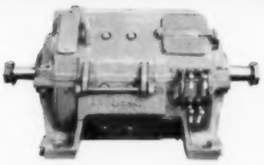

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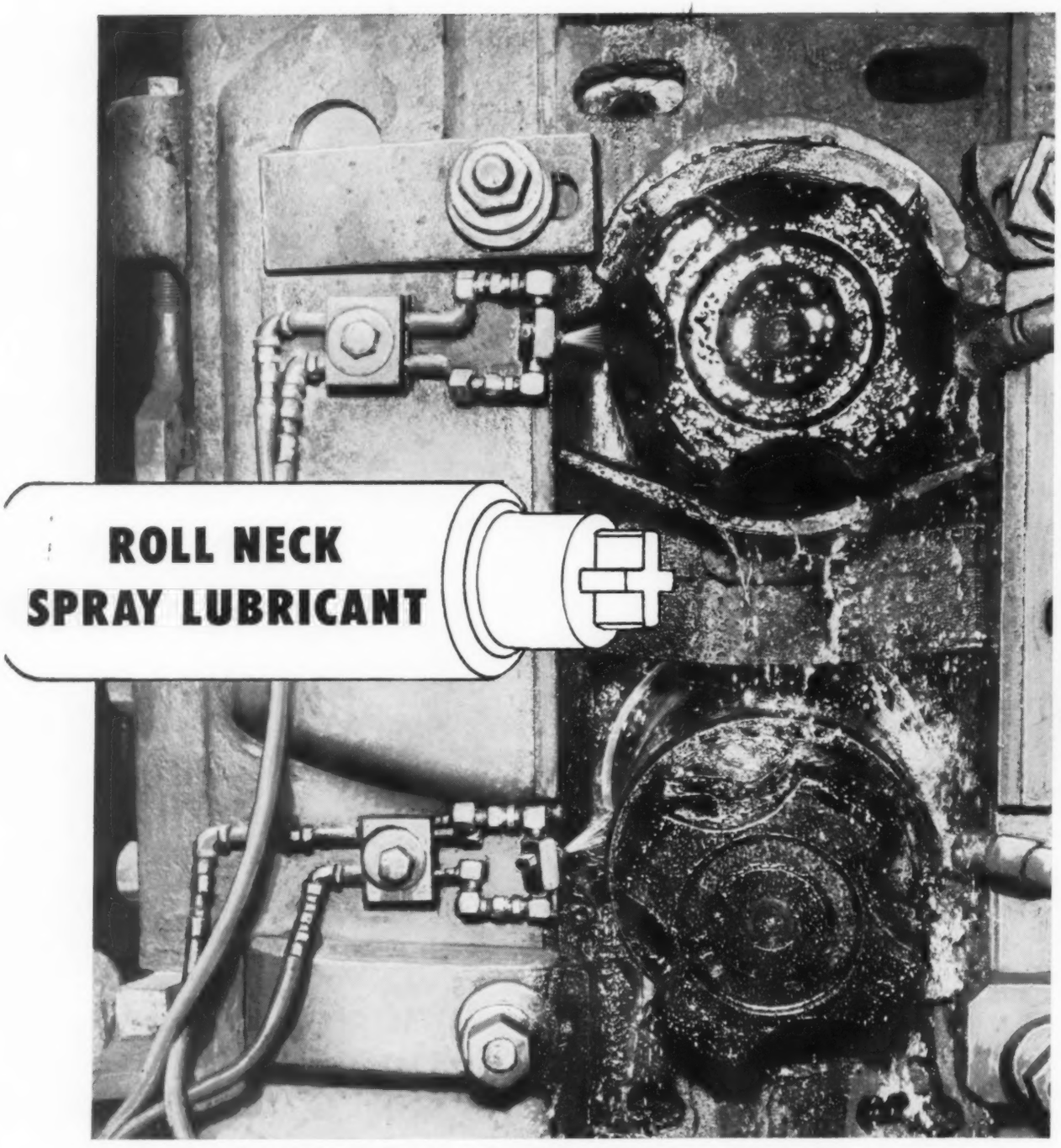

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1. **Blooming, Slabbing and Billet Mill Bearing life extended.**
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First adapted in 1949 and now being used by major steel companies for this important and severe application, KLINGFAST, a lead base fluid lubricant retains its film strength (4 gram Timken test, 30 minute minimum—43 lbs. L.A.L.)

For complete data, write for Bulletin K-26

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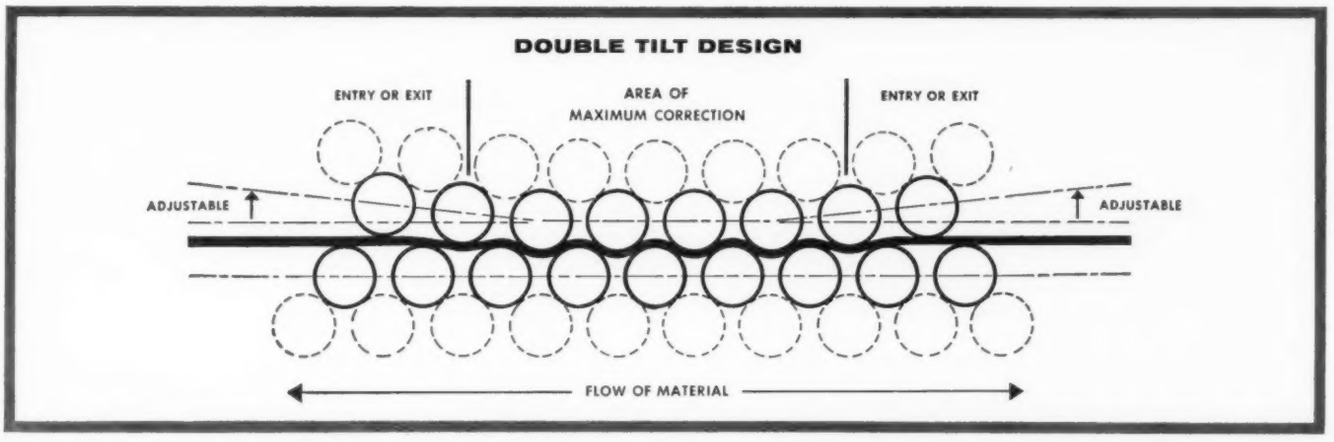
SUTTON-MAUST
double-tilt Roller Levelers

For sheets, plate and strip
including tension leveling of coil stock

- Better flatness and shape correction in all modern metals.
- Easier feeding, no pinch rolls are required, entry marks are eliminated.
- Roll design is symmetrical, work flow is reversible without adjustment.

Sutton-Maust double-tilt, backed-up roller levelers provide the finest precision flattening and correcting of ferrous and non-ferrous sheets and strip. Accuracy obtained, easily meets or betters the most critical expectations.

All sizes are available for all modern metals of any required width and in gauges from .001″ to .750″. They may be used for both sheets and coils in process lines, cut-to-length lines and tension leveling lines. Motorized adjustments permit remote control in processing lines.



Maust patented, double-tilt design provides highest accuracy of flatness available

In the exclusive double-tilt design, the top work rolls are arranged in a symmetrical pattern with the entry and exit rolls tilting slightly upward. The entry rolls subject material to gradually increasing waves, the centrally located roll group produces a series of uniformly deep waves for maximum correcting work and the exit group completes the flattening process perfectly.

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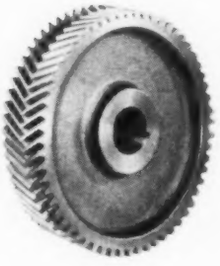

Whether it is in machine tools, steel mills, cement mills, paper mills, chemical plants, construction equipment . . . machinery of any kind . . . this dependability, proven by performance, means true economy that has resulted in enduring customer satisfaction.

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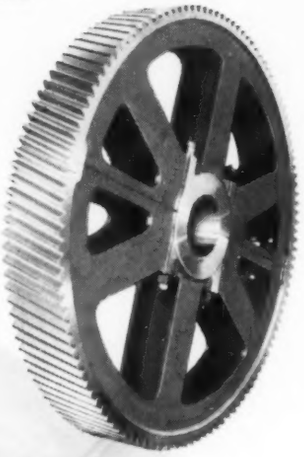

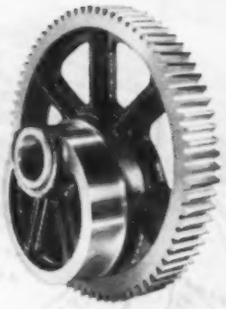

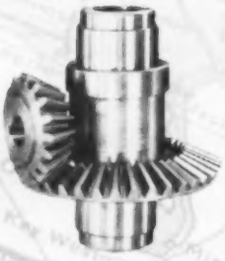

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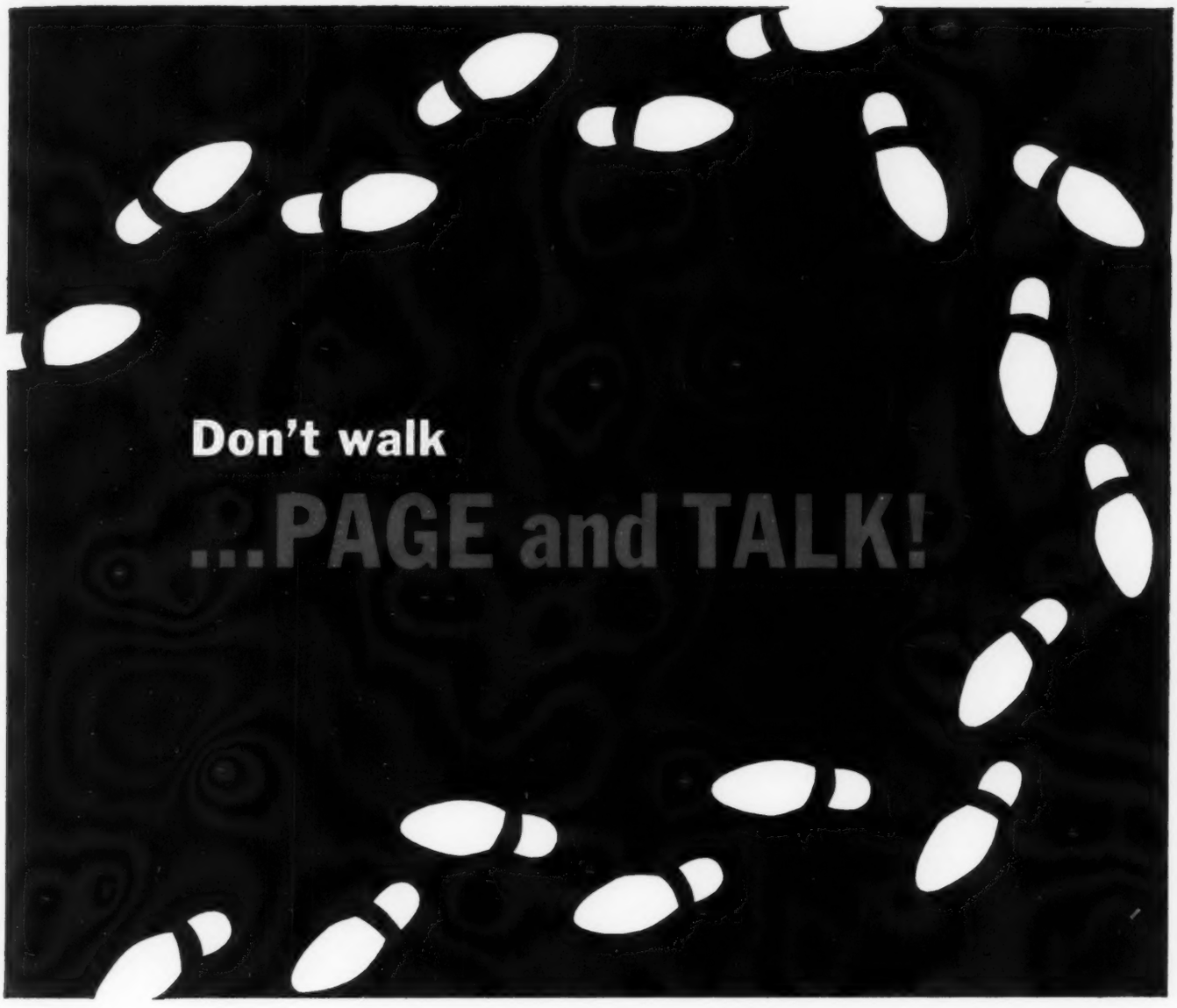

Femco-Phone Systems for every Steel Industry application

Time is just about the most expensive commodity in the steel industry today.

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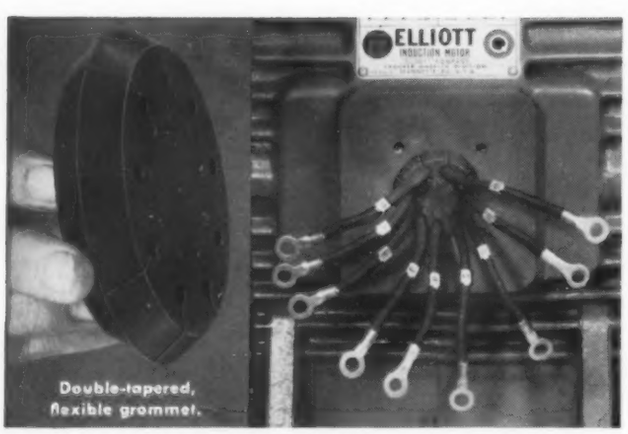
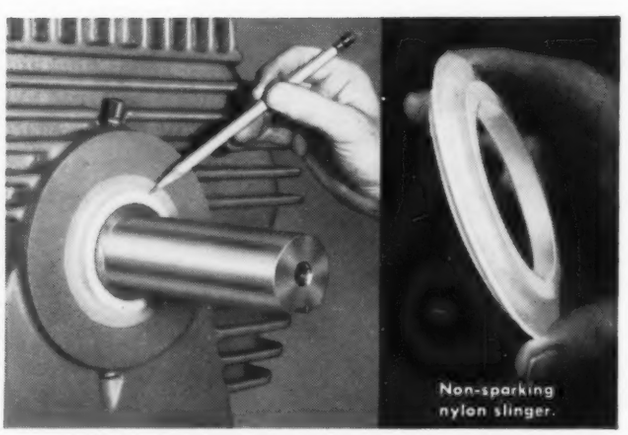
COMMUNICATIONS: Carrier and wired audio systems for all mining and industrial applications. **MONITORING:** Fans, circuit breakers, valves, pumps, compressors, etc. **TELEMETERING:** Flows, pressures and other functions. **REMOTE CONTROL:** Pumps, valves, circuit breakers; soaking pit covers, furnace doors; cranes, or other moving equipment.

better protection and better cooling make Elliott C-W SEALEDPOWER MOTORS outstandingly



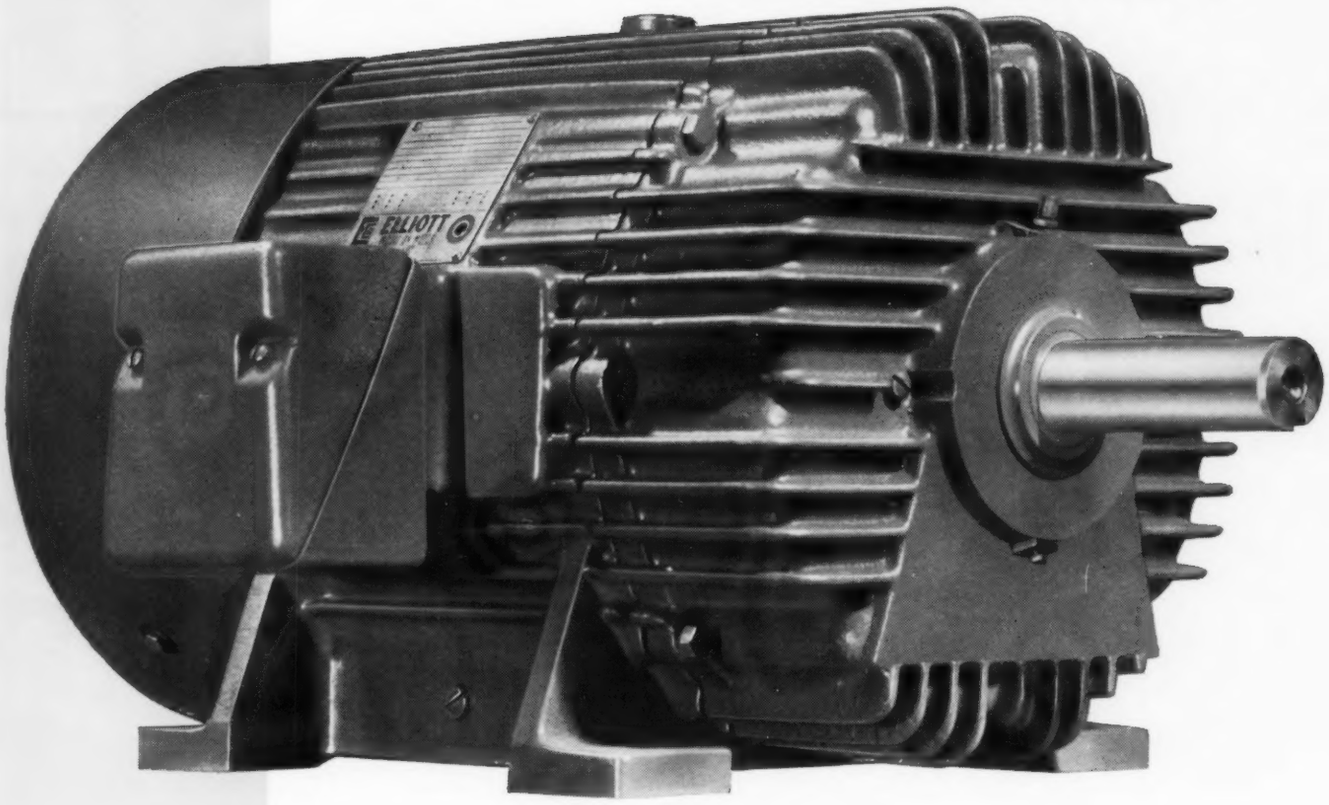
TIGHTLY COMPRESSED GROMMET seals leads where they leave motor frame. Grommet is compressed around numbered leads by pressure ring. No leakage here.



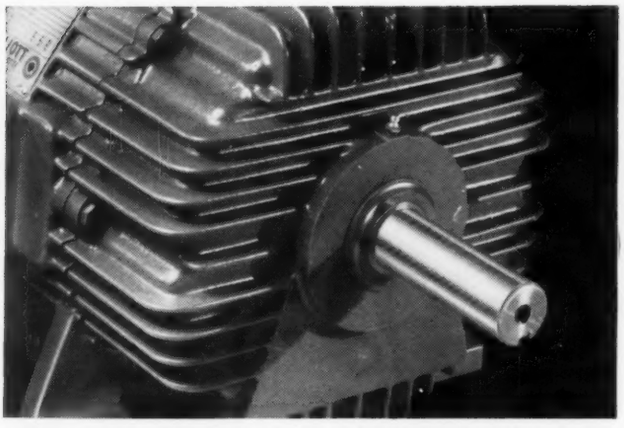
ROTATING SLINGER BANISHES MOISTURE, DIRT that otherwise might creep along shaft and through bearing. Recessed into bracket, it provides long labyrinth-type seal.

IMPORTANT FACTS
about enclosed motors are given in new Elliott Bulletin PB-6000-2. Send for free copy today.

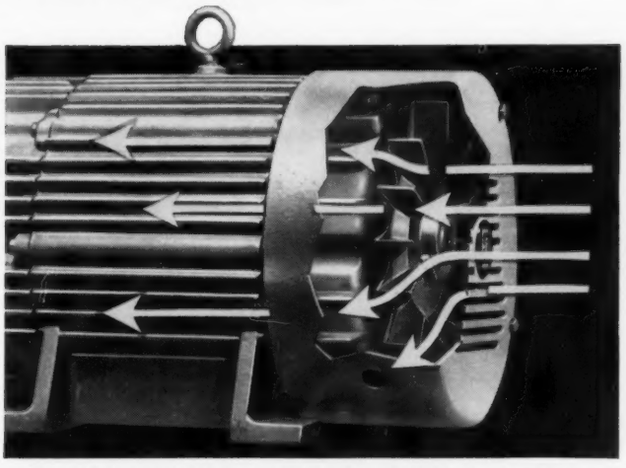
Elliott C-W ribbed-frame enclosed motors, pioneered in the United States by Crocker-Wheeler, include ratings up to 300 hp.



dependable!



MORE AND DEEPER HEAT-RADIATING FINS have greater cooling area. Generous fins over rear bracket keep bearing cool. Non-clogging, easy to clean.

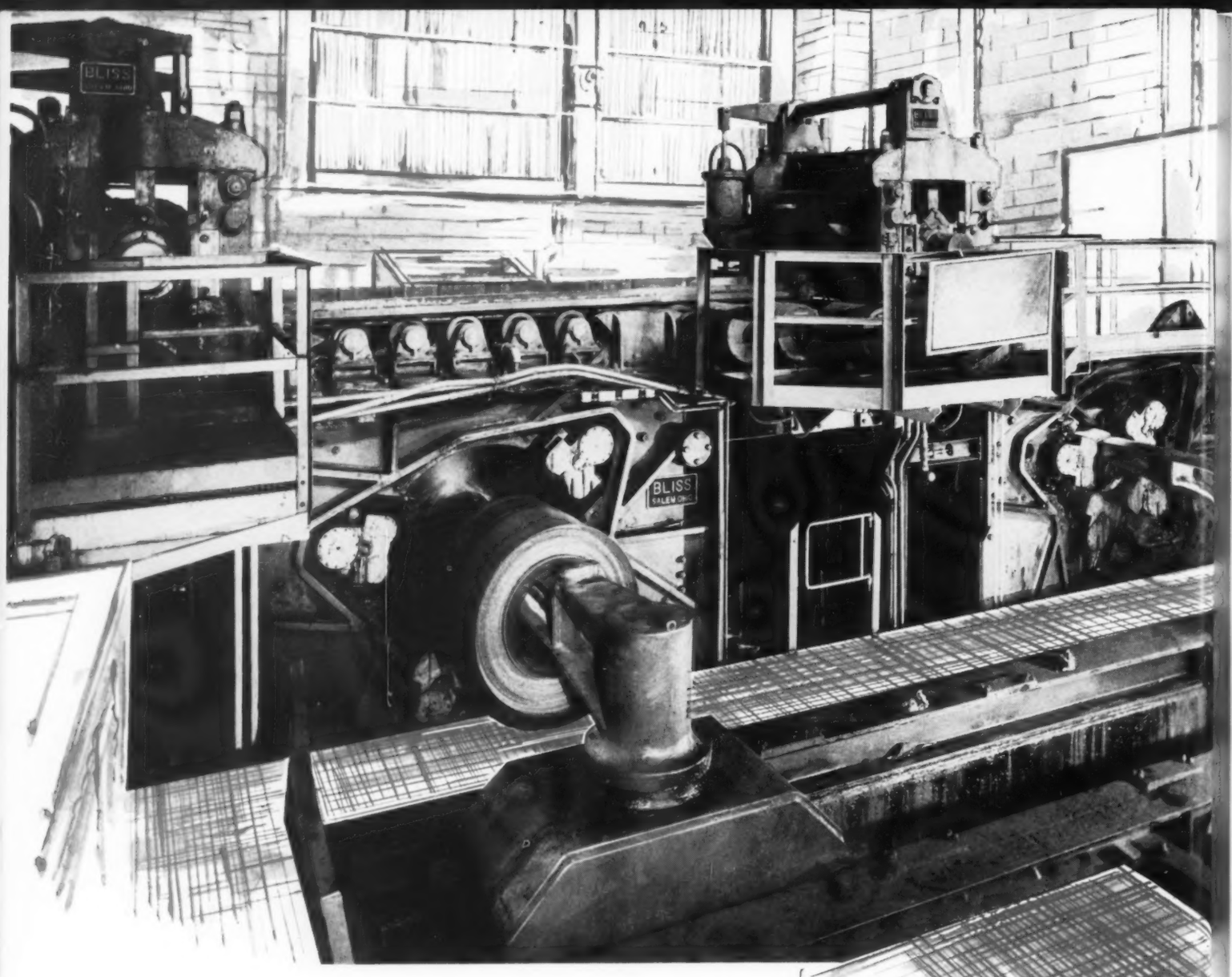


COOLING AIR BLAST FROM EXTERNAL FAN, directed by fan cowl, hugs entire length of motor. Non-sparking fan has keyed and clamped split hub.

ELLIOTT Company

CROCKER-WHEELER PLANT • JEANNETTE, PA.

W9-1



FROM MILD STEEL TO STAINLESS

It's all the same to these two Bliss coilers at Armco

These smooth-running Bliss downcoilers on the new 56" hot strip mill at Armco Steel Corporation's Butler, Pa. Works, coil everything from flexible mild steel to tough, springy stainless steel strip. Bliss coilers, with their expanding mandrels and positive wrapping action were used because of the variety of gages and alloys to be put through the new mill. In the Bliss design, the mandrel keeps the strip in tension during coiling; wraps a tight, smooth-edged coil without surface scratches or marks. Blocker rolls retract as soon as leading end has been snubbed on the mandrel, and don't move in again until the trailing end is coming through the pinch rolls.

Besides the two downcoilers, Bliss' Rolling Mill Division designed and built the 100-yard-long runout table as another contribution to the Butler Works' handsome new hot strip line. For other examples of Bliss engineering for the ferrous and nonferrous industries, why not write for a free copy of the new profusely illustrated 84-page Bliss Rolling Mill Brochure, Bulletin 40-B? It describes the operation of Bliss mills and auxiliary equipment.

BLISS
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E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

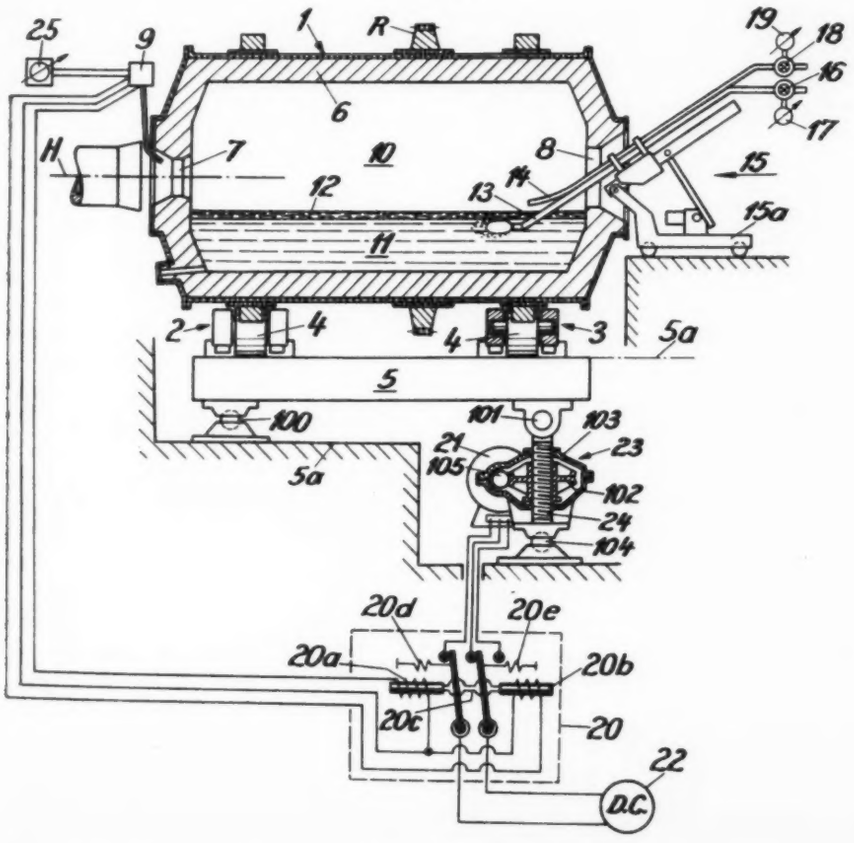
Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period March 24, 1959 through April 21, 1959.

REFINING METAL IN ROTARY FURNACES

△ U. S. 2,883,279, issued April 21, 1959, to Rudolf F. Graef and Ludwig A. von Bogandy, assigned to Huttenwerk Oberhausen Aktiengesellschaft, describes a method for refining metal baths in rotary furnaces by the injection of oxygen in such manner that the losses of energy due to unburnt carbon monoxide and unconsumed oxygen contained in the waste gases are reduced to a minimum.

Figure 1 shows a rotary furnace 1, in the outlet opening 7 of which is arranged a carbon monoxide measuring device 9. By adjusting flow indicators 17 and 19, it is possible to set valves 16 and 18 so that oxygen is injected at a predetermined ratio below and above the bath surface.

Figure 1



The carbon monoxide control instrument 9 which is set to control a desired value by means of the setting device 25, transmits deviations from the set CO content to a regulating relay unit 20 and activates, depending upon the excess or lack in carbon monoxide content of the waste gases, the motor 21 which derives its power from an electric power source 22. Depending on this activation, the motor operates the height adjusting device 23 of the adjustable furnace base plate 5 at the end where bearing 3 is mounted thereon, and either lowers or raises this base plate end, on which the bearing 3 supporting the right hand end of the furnace is mounted, by a corresponding rotation of threaded pin 24.

The level of the bath in the interior of the furnace can thereby be determined, at will, for instance by setting the control gage 25 of the measuring instrument 9 to a desired value of the carbon monoxide content.

SUPPLYING OXYGEN TO BLAST FURNACE TUYERES

△ U. S. 2,879,056, issued March 24, 1959, to Elijah R. Wagner and assigned to United States Steel Corp., describes a system for adding oxygen to blast furnace tuyeres at rates which are automatically pro-

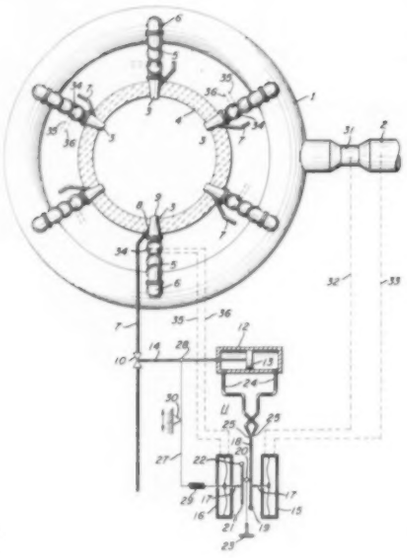


Figure 2

portioned to their respective rates of air supply.

As shown in Figure 2, each of the tuyeres 3 is provided with an apparatus for adding oxygen to the air blast which it delivers to the furnace from the bustle pipe 1. Each such apparatus consists of an oxygen supply conduit 7 which opens into a tuyere 3 for delivering oxygen to the air moving through it. A regulating valve 10 is provided in each conduit 7 for regulating the flow of oxygen through it.

Regulation of the operation of each valve 10 is controlled by an Askania ratio regulator 11. Then regulator 11 controls the actuation of a valve operator 12 in the form of a fluid pressure motor having a piston 13 for operating a piston rod 14 which has an actuating connection with a valve 10. The valve 10 is one which has linear operating characteristics such that the amount of oxygen supplied by the conduit 7 under its control is directly proportional to movement of its actuating rod 14 by the motor 12. The regulators 11 operate by proportionally balancing the amount of oxygen delivered through each conduit 7 to the rate of flow of air through each tuyere to deliver an oxidizing blast to the furnace from each tuyere in which the oxygen content is substantially constant and is predetermined according to the desired furnace operating conditions.

APPARATUS FOR QUENCHING AND REELING RODS

△ U. S. 2,880,739, issued April 7, 1959, to John D. Popp, assigned to United States Steel Corp., describes an apparatus for quenching hot rolled rods with water as they emerge from the last pass of the mill prior to being reeled into bundles.

In Figure 3, numeral 2 indicates the last roll stand of a hot rod mill. Rod R passes through the roll stand 2 into the bell mouth 4 of a guide pipe 6 and then into a bell mouth 8 leading into the water cooler box 10. The water quenching means consists of a number of sectional elements 12 within the box 10. As shown in Figure 4, each of the elements 12 is made up of concentric tubes 14 and 16 having a space 18 between them. The inner tube 14 is provided with a number of holes 20 drilled at an angle of 45 degrees to a radius through the wall in order to allow water to enter the inner portion 22 of the pipe 14 through which the rod R passes. Water is delivered into the space 18 from a header 24 through branch pipes 26. A pipe 28 connects the header 24 to the main water line. The flow of the water into the pipe 28 is manually controlled by means of valve 30 and is automatically controlled by means of a quick acting water valve 32 which is operated by a solenoid 34. The solenoid 34 is in an electric circuit including a power source L1 and L2 and a switch 36.

In order to provide for manual operation, a by-pass 70 is provided around the valve 32. A manually operated valve 72 is provided in the by-pass 70. The rod R passes from the cooling box 10 through a pipe 74 to the reel 76. The reel 76 has a housing 78 within which are guide pins 80 mounted on a member 82 which is rotated by means of gearing 84.

After the rod R passes through the first cooling section 12, it then passes through a guide 38, the construction of which is shown in Figure 5. When the rod R contacts the concave bottom end of cover 44 the cover 44 moves up around its pivot 46 to the broken line position shown. This pivoted movement raises rods 56 and 62 causing lever arm 54 to move to close the contacts of a switch 36 to complete a circuit to energize solenoid 34 to open quick acting valve 32. This starts the flow of water into the header 24, then into the space 18 and then through the holes 20 to spray the rod passing therethrough. The uncooled forward end portion of the rod will readily wrap itself about the pins 80 of the reeler, thus eliminating cobbling. Once the rod is securely wrapped

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or assignee
2,878,518	3/24/59	Preparation of ferrosilicon particles...	Knapsack-Griesheim A.G.
2,878,538	3/24/59	Chill pad for an ingot mold	Elmer E. Theis
2,878,582	3/24/59	Apparatus for handling coiled rod bundles	United Engineering and Foundry Co.
2,878,697	3/24/59	Machine for rolling metal	Thompson Products, Inc.
2,878,869	3/24/59	Miscut mechanism for flying shears	United Engineering and Foundry Co.
2,878,918	3/24/59	Rolling mill transfer	Birdsboro Steel Foundry & Machine Co.
2,879,156	3/24/59	Treatment of a melt with briquetted substances	Fredrik J. O. Hurum
2,879,194	3/24/59	Method of aging iron-base austenitic alloys	Westinghouse Electric Corp.
2,880,083	3/31/59	Production of sponge iron	R-N Corp.
2,880,085	3/31/59	Ferritic alloy steels for use at elevated temperatures	Firth-Vickers Stainless Steels, Ltd.
2,880,109	3/31/59	Coating the interior of steel cylinders with a nickel base alloy	United States Steel Corp.
2,880,778	4/7/59	Apparatus for pulling the end from a coil of strip	United States Steel Corp.
2,880,855	4/7/59	Method for heating, descaling, and lubricating steel while working it	La Salle Steel Co.
2,880,889	4/7/59	Kickout device for coils	United States Steel Corp.
2,881,068	4/7/59	Treating ferrous melts with porous sintered materials	Wargons Aktiebolag
2,881,107	4/7/59	Austempered, cold-finished steels	La Salle Steel Co.
2,881,108	4/7/59	Annealed, cold-finished steels	La Salle Steel Co.
2,881,109	4/7/59	Case-hardened, worked steels	La Salle Steel Co.
2,881,488	4/14/59	Tilting ladle	Koppers Co., Inc.
2,882,844	4/21/59	Soaking pit furnace	Hermann Romer
2,883,039	4/21/59	Lubricating guide for wire drawing	Bethlehem Steel Co.
2,883,280	4/21/59	Ferrous base alloy	General Motors Corp.
2,883,281	4/21/59	Air hardening graphitic steel	The Timken Roller Bearing Co.

3-stand roughing mill train driven by a single motor using 3 special Western Gear combination pinion stand speed reducers to distribute power to housing locations.

BIG POWER–SMALL SPACE

Combination double reduction right angle reducer pinion stand, 3.7:1 ratio, rated 1500 HP AGMA Class 1 at 200 RPM input.

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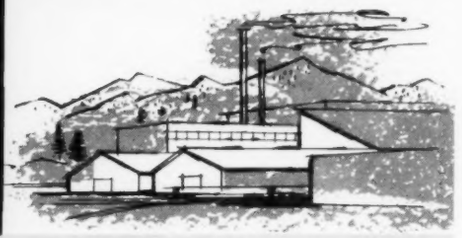

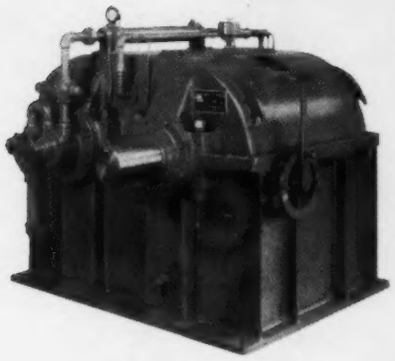

Two-speed herringbone reducer for midwest steel mill installation, ratios 1:1 and 1.5:1, rated 3500 HP AGMA Class 1 at 900 RPM input, driven by a 1750 HP motor.

WG

As part of the recently completed plant expansion program of a major steel producer in the Seattle, Washington area, roughing mill stands were set in a widely separated continuous arrangement. **Problem:** How best to locate large power feed shafts between reduction gears and mill stands.

Engineering and cost-reduction studies by Western Gear's Seattle Engineering Group resulted in the efficient mechanical power distribution sketched here. Western Gear plants and engineering facilities are ready to assist **you** in solving any problem of mechanical power distribution.

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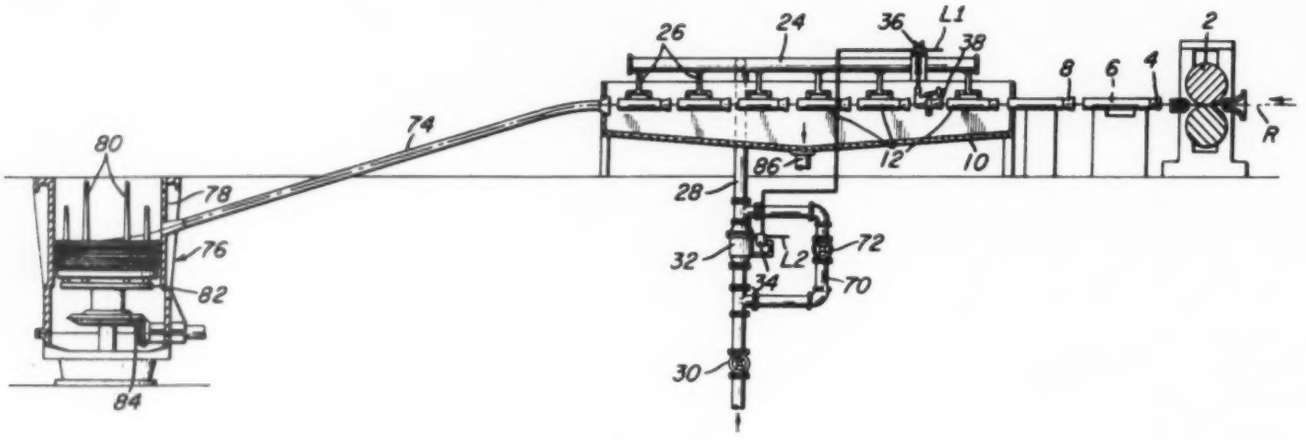

Figure 3

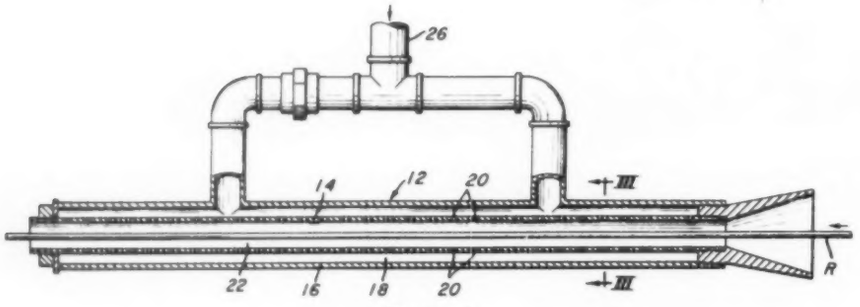

Figure 4

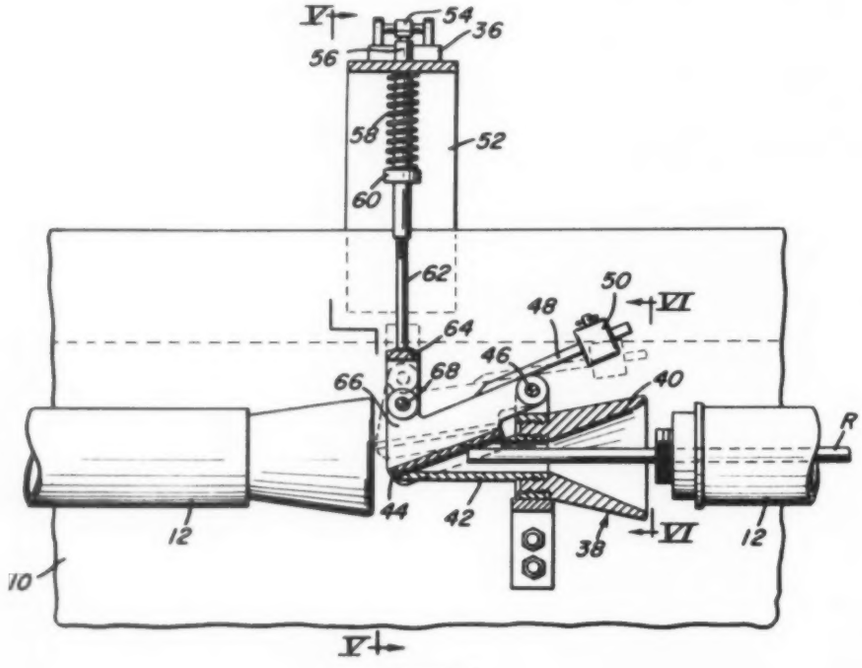

Figure 5

around the pins 80 the quenched rod will follow without damage. After the rod R passes from under the cover 44 the spring 58 will bias the rods 56 and 62 downwardly to return the cover to its normal position, thus opening the contacts so that the valve 32 will close and water will drain from the cooling sections 12 into the cooling box 10 and through a drain pipe 86. The apparatus will then be ready to receive the next rod.

TREATMENT OF WASTE PICKLE LIQUOR AND COKE OVEN GAS

△ U. S. 2,880,061, issued March 31, 1959, to George E. Muns and Donald C. Berkebile, assigned to Crucible Steel Co. of America, describes a process of reacting waste sulphuric acid pickle liquor from steel mills with raw coke oven gas in such manner as to recover a number of valuable products, with substantially no residual waste materials.

In the process of the present invention, raw coke oven gas is reacted with spent pickle liquor instead of with fresh sulphuric acid. This results in conservation of sulphuric acid. The process of the present invention is such, as described below, as to result in the recovery of ammonium sulphate, iron oxide, elemental sulphur, pyridine and ferrocyanides as well as the resultant substantially purified coke oven gas, which is thus rendered a suitable source of heat for steel mill applications.

In general, the process consists of establishing a countercurrent flow of the liquor and gas in a vertical absorption tower and so adjusting the rates of flow as to establish and maintain a pH value at the base of the tower of about 7.5 to 7.8, thereby to produce aqueous ammonium sulphate solution and insoluble iron sulphide, ferrocyanide and pyridine compounds; withdrawing the reacted slurry from the base of the tower and oxidizing with agitation at a pH of about 6.8 to 7.8 to drive off pyridine and to decompose iron sulphide and to form iron oxide; continuing the oxidation until the iron sulphide is reduced to not less than about 0.2 to 9.5 per cent by weight of the total slurry, centrifuging the resulting slurry to separate the ammonium sulphate solution from the solids comprising the insoluble iron oxides, ferrocyanides and sulphur; mixing the resulting slurry with alkali to solubilize the ferrocyanides, recovering the free sulphur of the slurry by flotation, centrifuging the resulting slurry to separate ferro-

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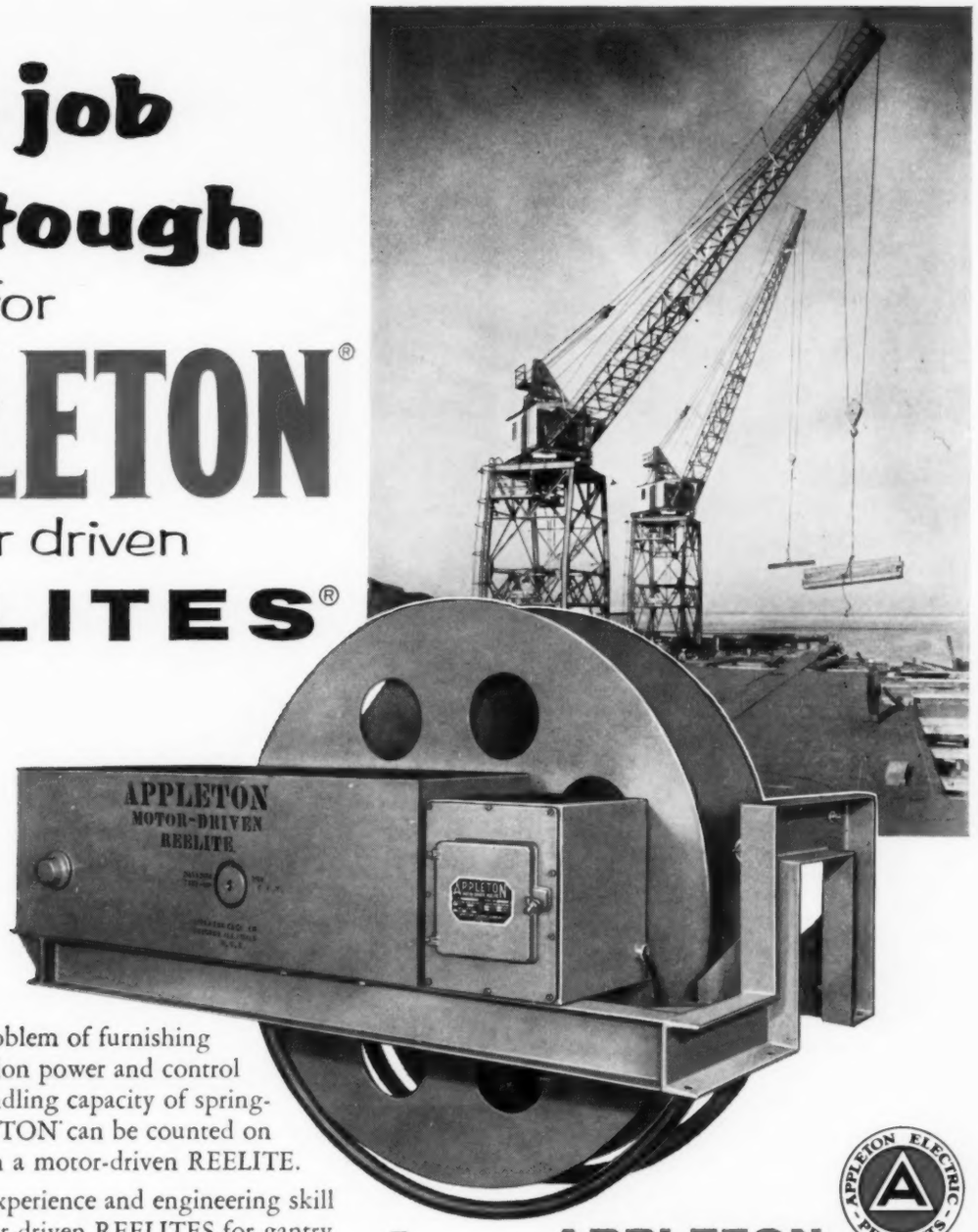

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APPLETON'S experience and engineering skill in designing motor-driven REELITES for gantry cranes, material handling equipment, traveling bridges, magnet application, etc. is known the world over.

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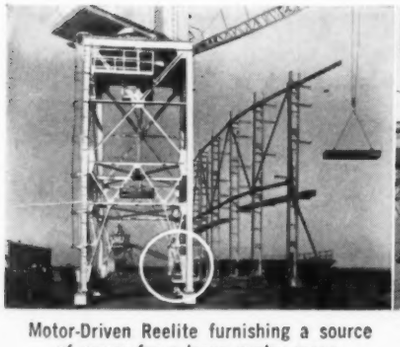
Motor-Driven Reelite furnishing a source of power for a large gantry crane.

Motor-Driven Reelite installed on movable crane in large coal yard.

Typical installation of Motor-Driven Reelite applied to over-bridge travel application.

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Mixer-type
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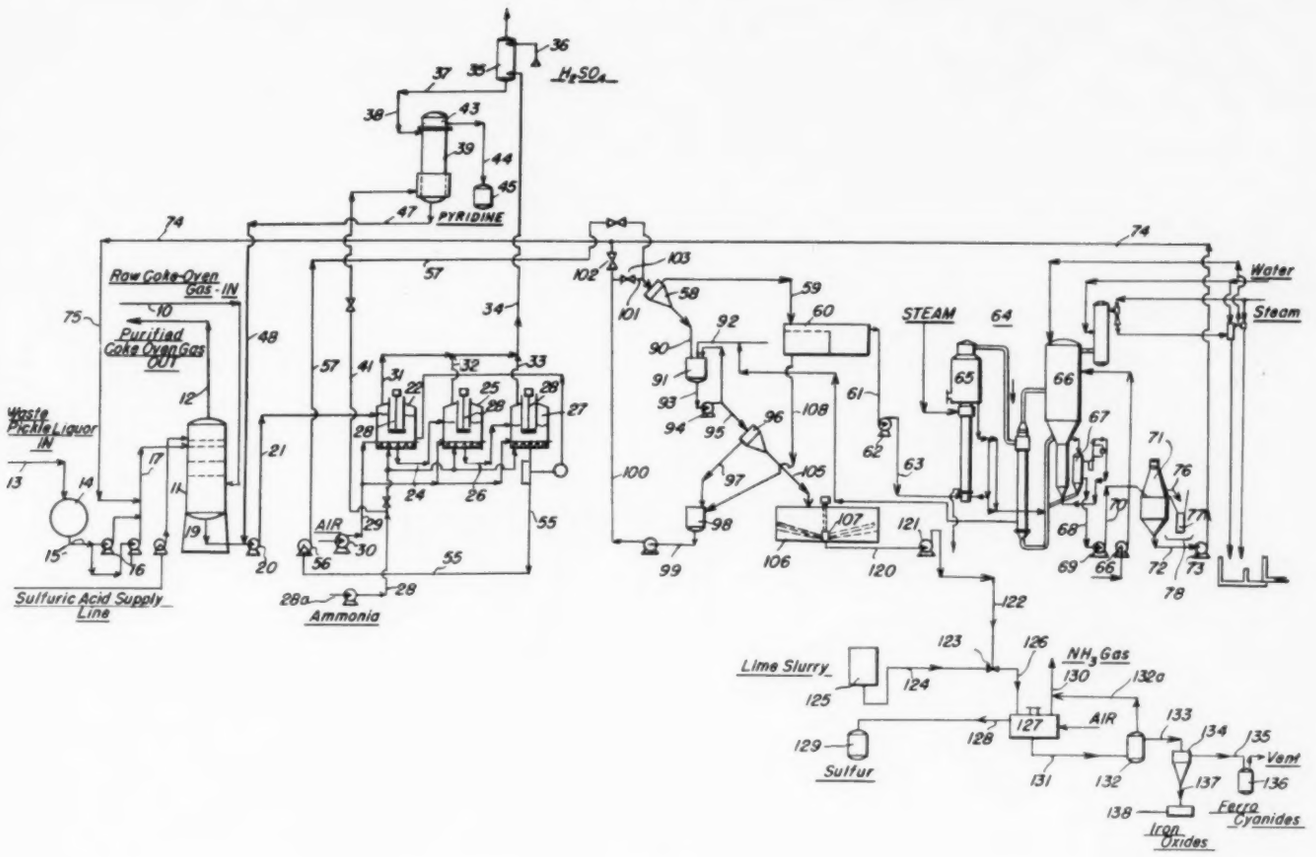


Figure 6

cyanides from the iron oxide, and recycling a portion of the iron oxide to the absorption tower for increasing the hydrogen sulphide recovery.

The process is shown schematically in Figure 6.

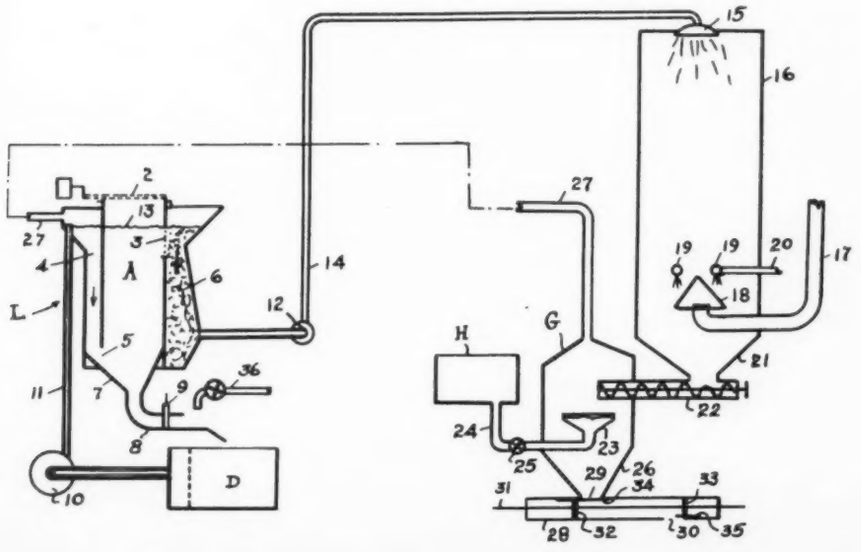
PRODUCTION OF FERROUS SULPHATE

△ U. S. 2,880,062, issued March 31, 1959, to Charles B. Francis, assigned to Puriron and Chemicals, Inc., relates to the production of ferrous chloride and ferrous sulphate from siderite, limonite and hematite iron ores, from which a substantially carbon-free sponge iron and/or iron powder may be produced.

The process consists of gradually feeding iron ore in comminuted form into a relatively deep body of an aqueous solution of hydrochloric acid and during the descent of the ore in the solution reducing the ore to dissolved ferric chloride, feeding additional hydrochloric acid into the lower portion of the body of liquid and, by such feeding of additional hydrochloric acid plus feeding of ore, effecting the rise of ferric chloride solution and its flow from the upper portion of the body of liquid into contact with a mass of metallic iron. This converts the ferric chloride solution to a ferrous chloride solution, and removes the excess liquid from the latter solution to provide crystalline ferrous chloride, gradually delivering the ferrous chloride crystals to a pool of sulphuric acid and thereby producing ferrous sulphate, with an accompanying release and rise of hydrochloric acid gas from the pool of sulphuric acid, and feeding the gas with added water into the acid solution to provide the additional hydrochloric acid.

The process is shown schematically in Figure 7. The leaching apparatus is designated as L, the evaporator or drier as 16, and the reaction chamber for converting the dried ferrous chloride to ferrous sulphate as G.

Figure 7



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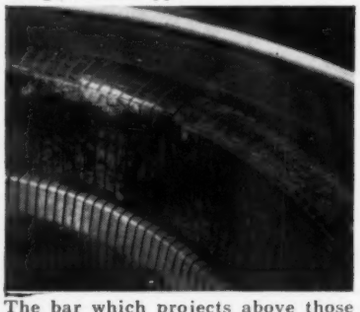
We look inside your commutator at National

...The Specialists in electric coils/repair service

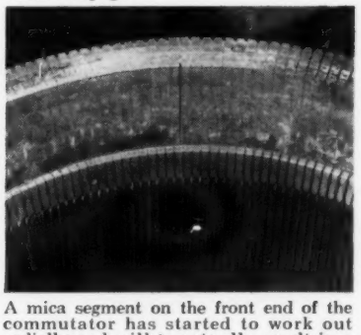
AND HERE'S WHAT WE OFTEN FIND!

Enlarged view of a dielectric puncture of a mica vee ring at the lower end of the copper bar. This is an example of interior commutator faults which may be present though exterior appears excellent.

Shifted or squirted mica at the apex of the 3° and 30° cone surfaces of a mica vee ring. The black lines on the 3°-surface were made by bar-to-bar voltage breakdown creepage.



The bar which projects above those adjacent has been locally overheated under a brush and softened.



A mica segment on the front end of the commutator has started to work out radially and will eventually result in a bar-to-bar short circuit.

When you send D-C machines to National for rewinding or rebuilding, the commutator gets a close inspection and test. But we've found from experience that a commutator that looks excellent on the surface may be in deep trouble inside... with mica cooked, varnish burned, loose copper, or imminent short circuits.

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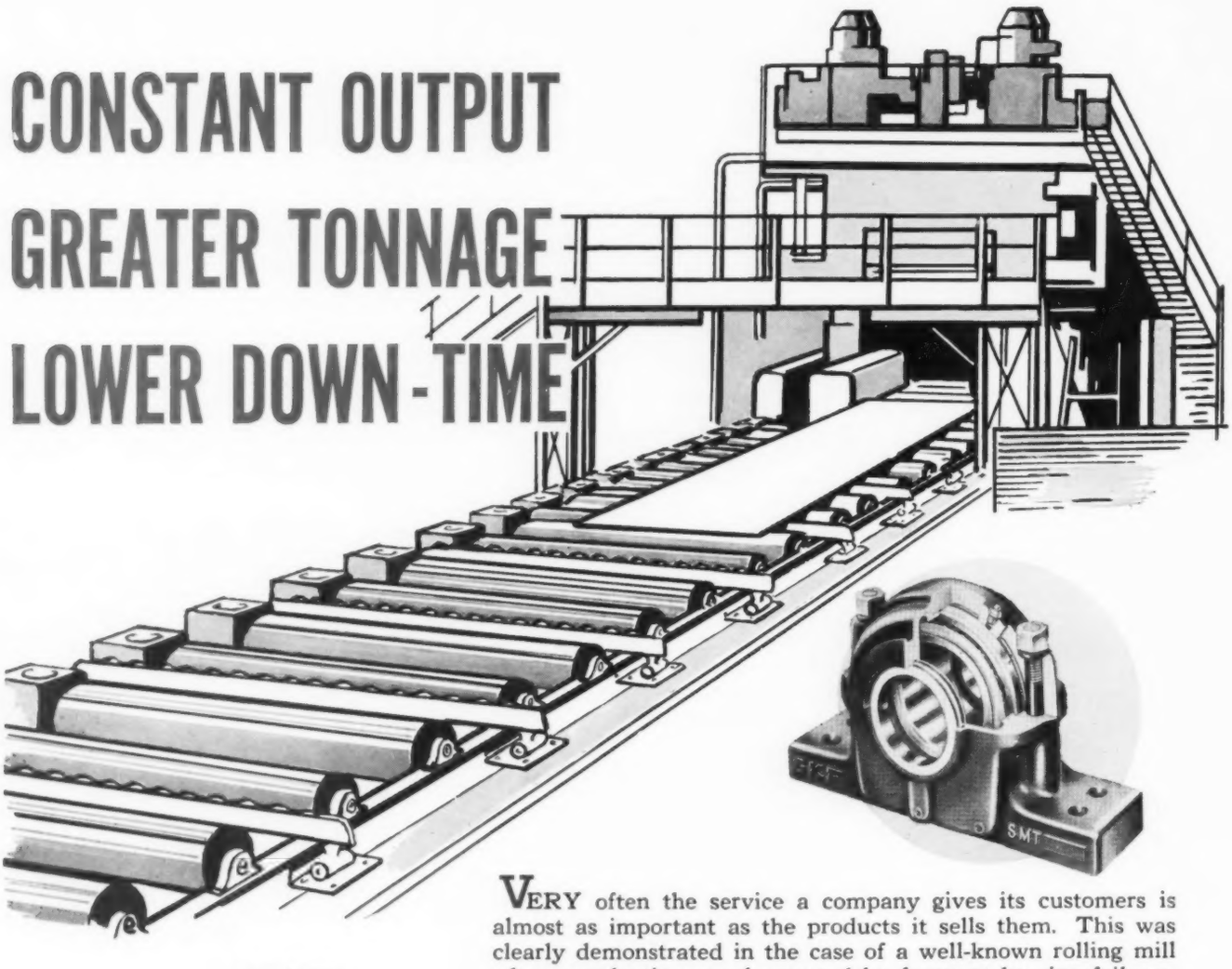
BERRY BEARING'S ENGINEERING SERVICE HELPS ROLLING MILL GAIN--

CONSTANT OUTPUT
GREATER TONNAGE
LOWER DOWN-TIME



VERY often the service a company gives its customers is almost as important as the products it sells them. This was clearly demonstrated in the case of a well-known rolling mill whose production was hampered by frequent bearing failures.

Berry's Engineering Department was asked to make recommendations. The suggested change over from plain bronze bearings to spherical roller bearings in the table solved the crucial problem--with a *significant increase in production* at *lower cost.*

And, what did the engineering cost the rolling mill? Not one cent! Such assistance is part of Berry's service to customers --large and small. So why not phone bearing headquarters today for anything you need in bearings, bearing specialties, transmission appliances, and engineering service. *You'll get immediate action,* as usual.

ANTI-FRICTION BEARING DISTRIBUTORS ASSOCIATION MEMBER AFBDA

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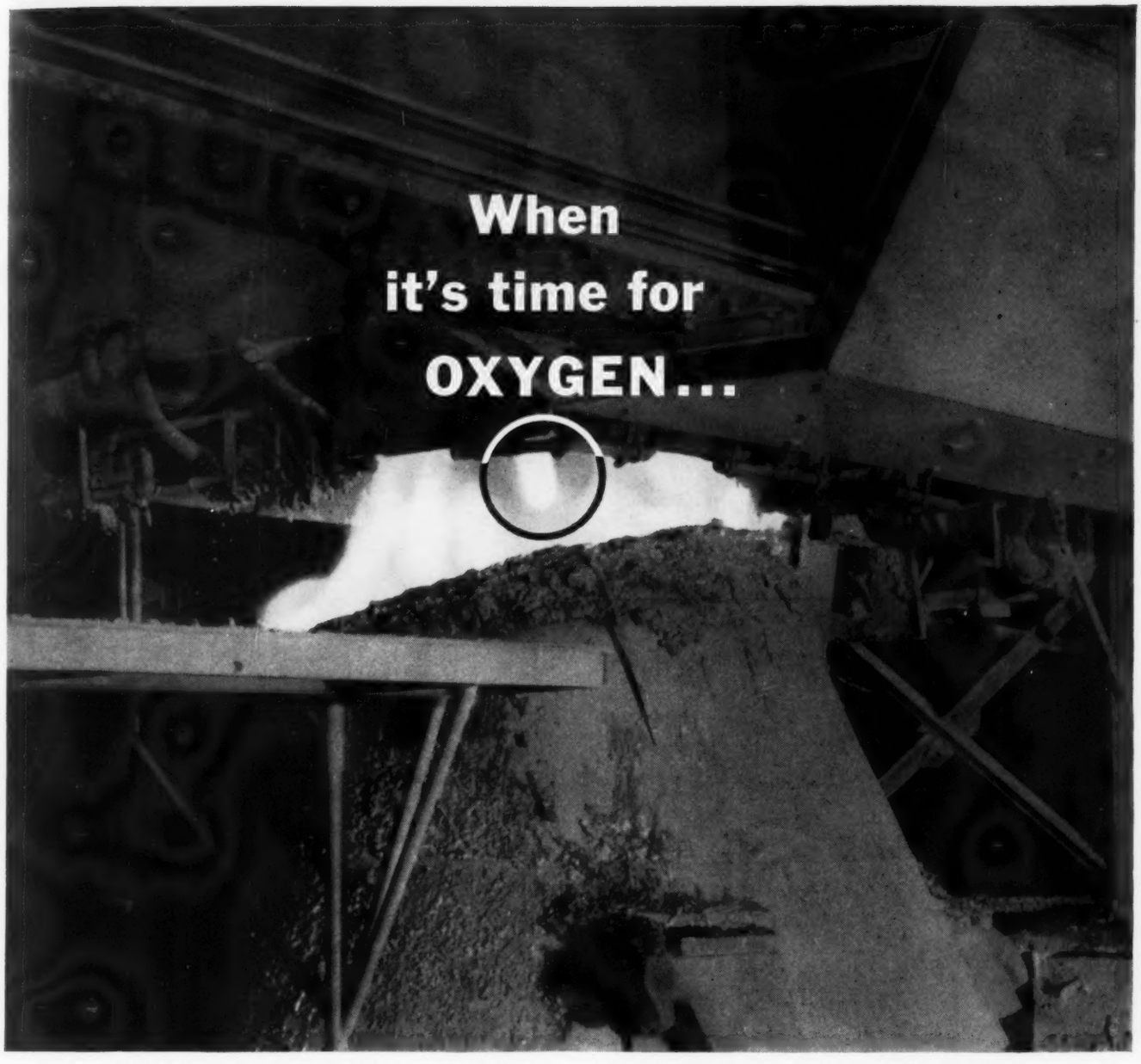


Basic oxygen furnace supplied by an Air Products on-site facility. Oxygen lance is circled. Air Products systems supply oxygen to individual users in tonnage quantities . . . including the largest single oxygen generator ever installed in a steel mill, rated at 525 tons per day.

When you plan to put oxygen to work . . . in your blast furnace, open hearth, oxygen converter, electric furnace . . . or for welding, cutting, scarfing . . . you will want a supply that is low in cost and dependable beyond question.

That's when it's time to call on Air Products.

. . . Because Air Products has the proved capacity to deliver oxygen economically and dependably . . . and to design, manufacture, install and operate complete systems for producing oxygen and many other vital industrial gases . . . in any quantities.

. . . Because on-site generating facilities, pioneered and perfected by Air Products, have made oxygen a low-cost utility . . . sliced its price by 80% in the last 12 years.

. . . Because you can profit from Air Products close participation in important technical developments in steel-making . . . from the broad experience Air Products offers from doing business with *all* major industries and defense agencies . . . from Air Products technical service, including development of new oxygen lance techniques.

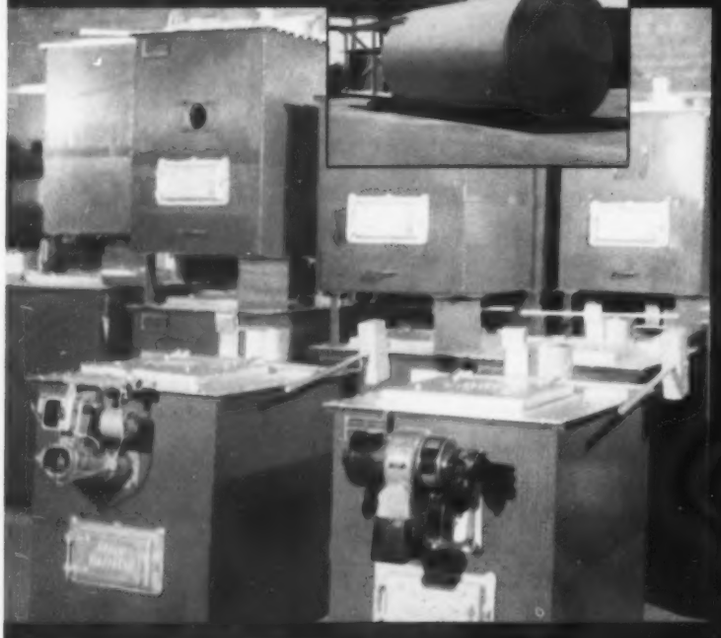
. . . *And because Air Products high-efficiency systems produce and deliver more oxygen at less cost than any other method.*

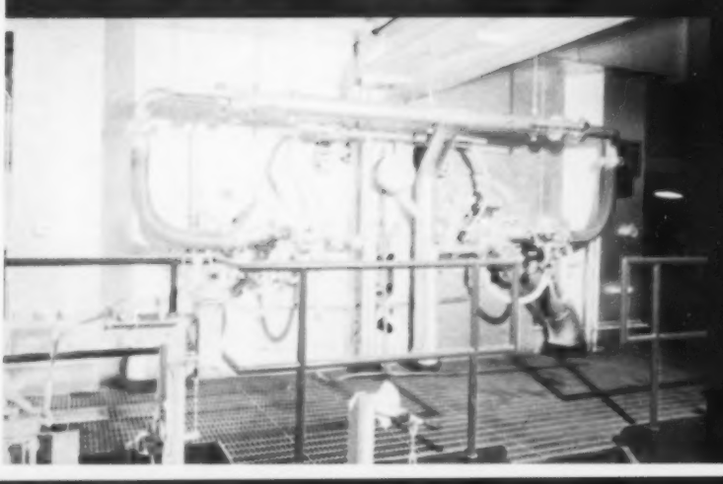
Air Products is ready to show you how you can have all the oxygen you need, without capital investment. Your inquiry is invited. Write, call or wire Air Products, Inc., Allentown, Pa. Phone: EXpress 5-3311.

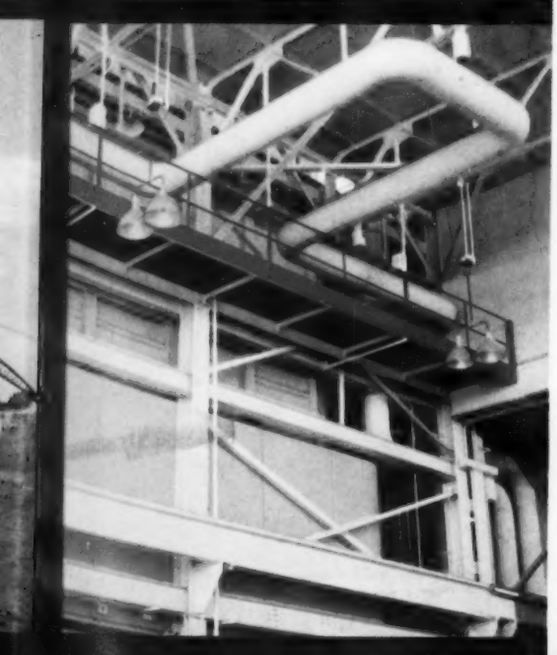
Air Products
...INCORPORATED

Bright, modern, functional

COLORS







...another important **Difference** in the Rust-Oleum System

How many coating manufacturers offer you a *complete system* that Stops Rust—and provides lasting beauty over the years? The Rust-Oleum *System* does just that.

First—apply Rust-Oleum 769 Damp-Proof Red Primer directly over the sound rusted surface, after scraping and wirebrushing to remove rust scale and loose rust. The *specially-processed* fish oil vehicle in the primer penetrates rust to bare metal—merging the rust into the coating—saving costly surface preparations. *Second*—the wide variety of colors in Rust-Oleum finish coatings provides lasting beauty over the primer. Your choice of practically all colors from bright enamels to soft, restful pastels—all formulated for long over-the-years protection.

What is your coating problem? From Heat Resistant, Chemical Resistant, and Machinery Finishes to Heavy-Duty Top Coatings for use indoors and out—Rust-Oleum has the coating to meet your needs and the *system* for lasting beauty. Consult your Rust-Oleum Industrial Distributor . . . he has complete stocks for your use in maintenance, new construction, and remodeling. His experience can serve you well.

A matter of excellence.
Distinctive as your own fingerprint.

RUST-OLEUM®

STOPS RUST!®

RUST-OLEUM IS AVAILABLE IN PRACTICALLY ALL COLORS

SEE OUR CATALOG IN SWEET'S
OR WRITE FOR COPY

STOP RUST

with
RUST-OLEUM
769 Damp-Proof Red Primer

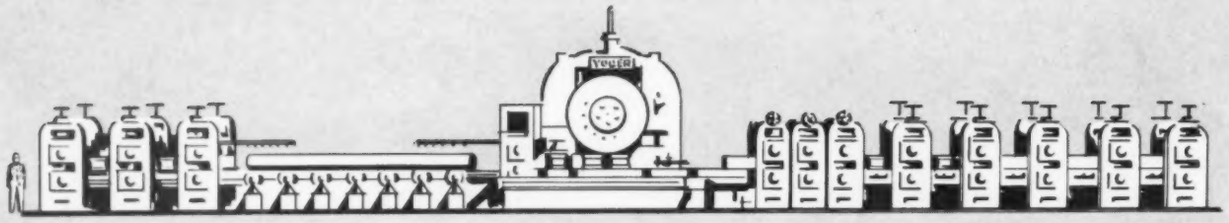
Eliminate costly surface preparations and save time, money, and metal. Just brush Rust-Oleum 769 Damp-Proof Red Primer right over the sound rusted surface—after scraping and wirebrushing to remove rust scale and loose rust. You can do this because the **specially processed fish oil vehicle** penetrates rust to bare metal—as proved by radioactive tracing studies.

SEND FOR FREE TEST SAMPLE! ATTACH TO YOUR LETTERHEAD!

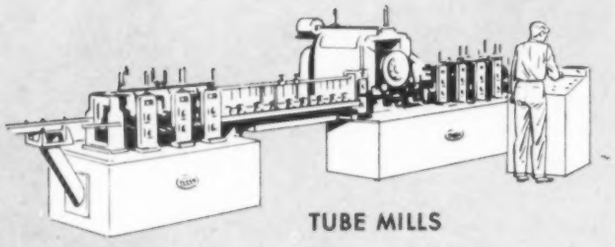
Rust-Oleum Corporation
2982 Oakton Street, Evanston, Illinois

Please send me the following at no cost or obligation:

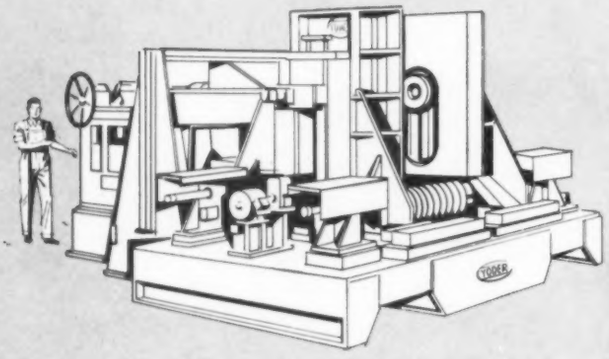
- ☐ Free test sample of Rust-Oleum 769 Damp-Proof Red Primer for rusted metal surfaces.
- ☐ Complete literature with applications and color charts.
- ☐ Information on matching special colors.
- ☐ Thirty-page report on Rust-Oleum fish oil penetration.



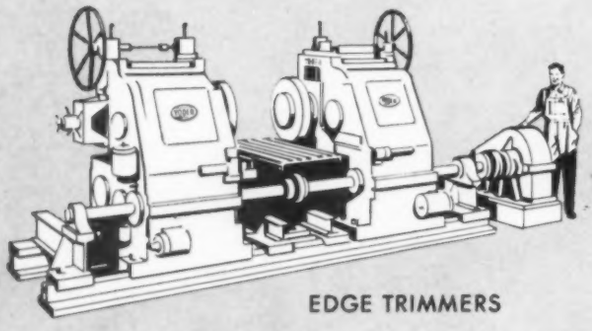
PIPE MILLS



TUBE MILLS



HEAVY DUTY UNCOILERS



EDGE TRIMMERS

YODER PIPE AND TUBE MILLS

Today's expanding markets and tightening economy demand closer production cost control. YODER'S complete line of ferrous or non-ferrous Pipe and Tube mills can help you meet production schedules economically . . . help you realize significant savings in the manufacture of tube and pipe.

YODER Pipe and Tube mills offer flexible production to meet fluctuating demand. They adapt easily to the most rigorous schedules. Everyday manufacture of constant high quality pipe and tube in diameter of 5/16″ to 24″. Speeds up to 350 fpm plus can be obtained with YODER mills.

YODER also makes a complete line of Slitting equipment and Cold Roll-Forming machinery. Send for your copy of the fully-descriptive book covering Tube Mill operation.

THE YODER COMPANY

5495 Walworth Ave. • Cleveland 2, Ohio

NON-FERROUS PIPE & TUBE MILLS

ENGINEERING **YODER** MANUFACTURING

PIPE AND TUBE MILLS (ferrous or non-ferrous)

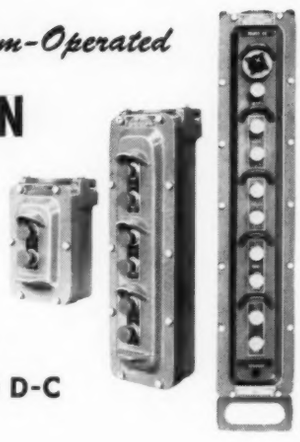
COLD ROLL FORMING MACHINES

ROTARY SLITTING LINES

For Hazardous Locations

Heavy-Duty, Cam-Operated

PUSH-BUTTON STATIONS



600 Volts
A-C or D-C

● The Euclid Electric & Mfg. Co. (Madison, Ohio) has added a complete new line of Pendant Push-Button Stations for all applications that necessitate NEMA Types 7 and 9 enclosures to meet hazardous-location requirements. Designed for heavy-duty applications, these cam-operated Stations are rated 600 volts, a-c or d-c. They are available from one to five speed-points in each direction for a total of eight circuits to provide for practically an unlimited number of different sequences of operation.

Sturdily constructed to withstand hard usage and abuse, their small cross- section permits comfortable, non-fatiguing, one-hand operation. Where required, a bottom holding handle can be supplied. The dense cast-aluminum enclosure can be readily opened for inspection of the silver-to silver contacts without disturbing any wiring. The conduit hole is threaded and a double-suspension cable hanger is provided.

Extra features include heavy-duty, control-circuit toggle disconnects, pilot lights, selector switches, and maintained-type contacts.

ASK FOR BULLETIN 2017

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

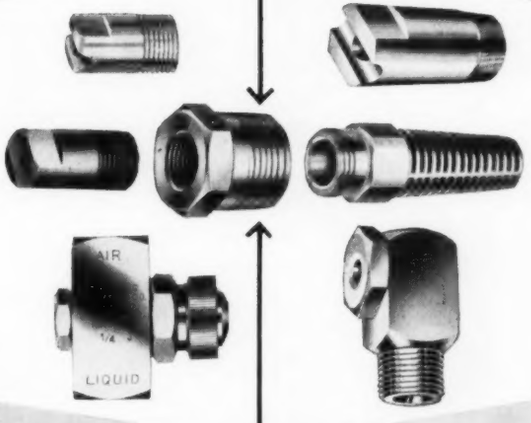
THE EUCLID ELECTRIC
EUCLID
AND MFG. CO., MADISON, O.

proved
SPRAY NOZZLE *design*

TO IMPROVE SUCH SPRAYING OPERATIONS AS

● DESCALING ● HOT STRIP COOLING ● ROLL COOLING ● COOLING SLABS—INGOT MOLDS — OPEN HEARTH TUNNELS — PIGS ● COKE CHEMICAL PROCESSING ● LUBRICANT SPRAYING ● AIR AND GAS WASHING

Whatever the application you will find Spraying Systems Spray Nozzles provide noticeable improvement in spraying operations . . . and often materially lower cost. Proved by performance. Supplied in a complete choice of types and capacities for selection of spray characteristics exactly as needed. Your inquiry is cordially invited.



SPRAYING SYSTEMS CO.
3262 Randolph Street • Bellwood, Illinois

For complete information write for Catalog 24 and special data sheet folder "Steel Mill Applications".

Water Wash: Mobilplex EP clings to surfaces even under direct water washing; also resists mild acids, metal-working emulsions.

Heat: Mobilplex EP holds consistency, resists runout at temperatures in the range of 300 F. Can be pumped at sub-zero temperature, has low shear resistance.

Extreme-Pressure: Mobilplex EP has shown excellent results in Timken OK-Load, 4-Ball Wear and similar tests. It has unusual capacity to withstand severe shock loads as evidenced by outstanding performance in heavy-duty equipment.

LABORATORY TEST SUMMARY RESULTS
MOBILPLEX EP (M) and 5 Leading Competitive EP Greases (A,B,C,D,E)

PROPERTY EVALUATED	RATING			
	Excellent	*Good*	*Fair*	*Poor*
Heat Resistance	M	A	C,D,E	B
Service Performance	M	A,C,E	B,D	
Extreme Pressure	M,A,C	B,D,E		
Anti-Wear	M,A	B,C	D,E	
Rust Protection		M,B,C, D,E		A
Water Resistance		M,B,C	A,D,E	
Handling Properties		M,A,B C D,E		
Controlled Bleeding		M,A,C	B,D,E	
Non-staining		M	A,B. D,E	C

announcing Mobilplex ep

The Multi-Service Grease with unique Calcium EP Complex. Never before in a single lubricant such a wide range of use . . . such a margin of superiority . . . such a potential for maintenance savings!*

From Mobil research comes Mobilplex EP . . . a Multi-*Service* extreme-pressure grease far superior in quality and range of applications to any multi-*purpose* grease available.

The unique Calcium EP Complex, special additives and extremely tenacious nature of Mobilplex EP, provide maximum protection against wear, rust, washout and heat. Because of its greater versatility, Mobilplex EP goes further than competitive extreme-pressure greases in simplifying your lubricant application, storage and purchasing problems. This new-type lubricant has given industrial machines greater protection while replacing as many as seven other greases. Mobilplex EP has all of the advantages usually associated with EP greases—as well as excellent storage, structural and oxidation stability.

Examination of the laboratory summary at left shows that in comparison with five leading extreme-pressure lubricants Mobilplex EP is the *only* grease excellent or good in every grease quality tested. No wonder aluminum and steel plants, forging and metal-drawing shops, the cement, chemical and rubber industries, steel and paper mills are reporting dramatic success with Mobilplex EP.

For full details contact your Mobil representative.

Mobil

**Multi-Service means ideal for all types of anti-friction and plain bearings under all normal operating conditions (temperatures in the range of 300 F.) and for all types of dispensing equipment.*

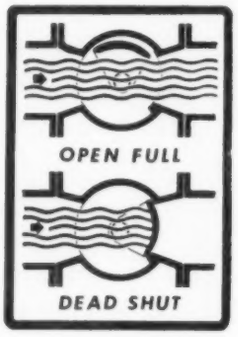
Proved Petroleum Products . . . Available with a Mobil Program of Correct Lubrication

THERE'S NO MAGIC in a DeZurik Valve.. it just SEEMS that way!

DeZurik Valves have so many advantages over ordinary valves it may seem too good to be true. They open easily . . . close tight . . . open or close with a quarter-turn . . . need no lubrication . . . never freeze! What accounts for this seeming magic?

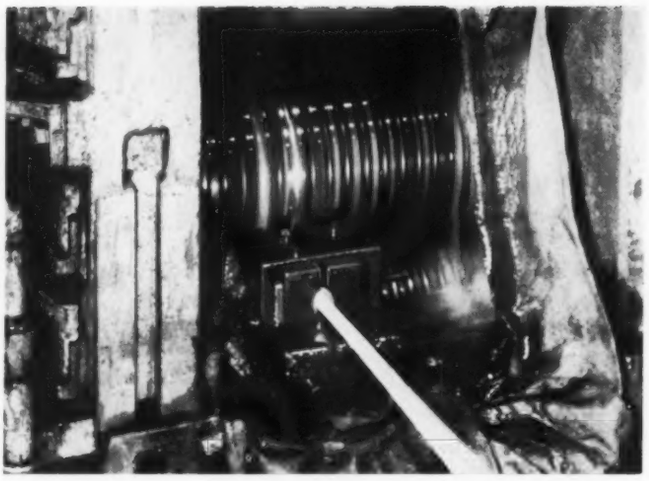
ECCENTRIC ACTION

This principle, exclusively DeZurik's, permits the plug to touch the valve body *only* when the valve is closed. The resilient plug-facing seals tight every time on any line. Opening the valve backs the plug away from the seat and the plug swings open easily . . . without friction . . . without lubrication!



DeZurik Valves are available in a full range of models and metals and in sizes from ½" thru 20" with lever, gear, or remote operation. See the DeZurik representative in your area, or write for details.

DeZURIK CORPORATION
SARTELL, MINNESOTA



Near-white-hot rod enters roller guide housing, and forming rolls beyond. Colmonoy hard surfacing rebuilds worn guides, gives them longer life than before.

Colmonoy Cuts Roller Guide Reclamation Cost

Hard-surfacing alloys that are easy to apply save welding time. And it follows that finishing time is also reduced—easy-applying alloys produce smoother deposits. Time is money, and the maintenance department of a large stainless steel bar mill saves money by using Colmonoy No. 6 alloy to reclaim worn roller guides. With Colmonoy they reclaim three guides in the time it took to do one previously.

The superior wear-resistance of Colmonoy No. 6 added more savings by extending even further the service life of the guides. All roller guides in this plant are reclaimed with Colmonoy—again and again, indefinitely.

Colmonoy alloys are being used in many mill operations: on plate guides, edger rolls, journal sleeves, and coolant-pump parts. Write for complete information.

Smoothness is the notable characteristic of these Colmonoy-protected guides prior to finishing.

Roller guide being overlaid with Colmonoy No. 6 rod. Work rotation is operator controlled.

Ready for further service are these finished guides with mirror-bright Colmonoy surfaces.

HARD-SURFACING AND BRAZING ALLOYS
WALL COLMONOY CORPORATION
19345 John R Street • Detroit 3, Michigan
BIRMINGHAM • BUFFALO • CHICAGO • HOUSTON • LOS ANGELES
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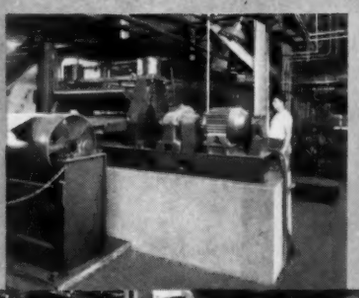
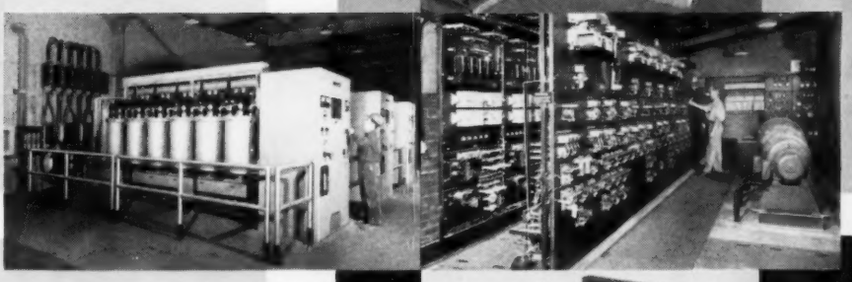
ALLIS-CHALMERS... in step with **STEEL**

complete electrical systems coordination by Allis-Chalmers:



MOTORS



MERCURY ARC & SEMI-CONDUCTOR RECTIFIERS

CONTROLS

FURNACE TRANSFORMERS

single engineering responsibility... superior end results

Planning to modernize, expand or erect new mill facilities? You'll achieve better end results, more efficient operations with the Allis-Chalmers *coordinated* electrical equipment program.

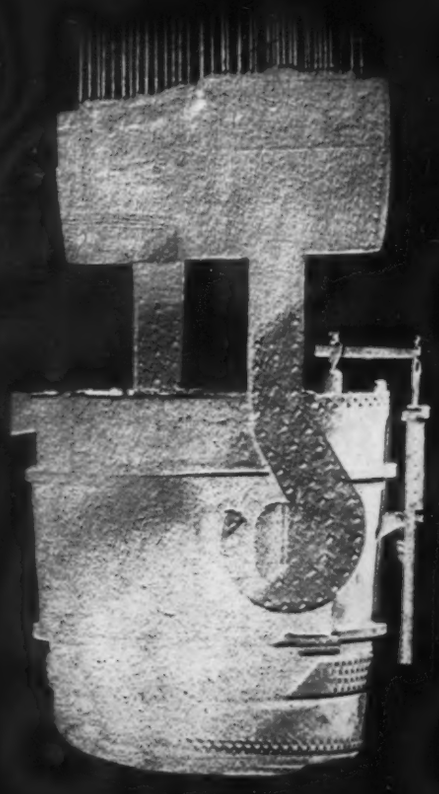
A-C steel mill specialists submit a *complete* proposal package — from system engineering, product application and installation to operation and service. One-source savings are substantial. Operation is *guaranteed*. Call in the engineering expert that *knows* electricity — Allis-Chalmers.

Your nearby A-C representative will assist you with preliminary electrical planning help. He'll show you how A-C integrates the equipment illustrated on the following pages.

ALLIS-CHALMERS AC ALLIS-CHALMERS

A-1169-1S

HAUNTED BY DOWN TIME?



PACECO cranes can set your mind at ease. Rugged–dependable–with simplified maintenance requirements. PACECO cranes speed production and build profits.

benefit with PACECO'S newest crane developments

New concepts in crane controls, full anti-friction bearing machinery components, and compact trolley machinery arrangements mean lower first costs and minimum maintenance. PACECO'S 36 years of design and fabrication leadership make PACECO cranes better cranes to meet the rigid demands of mill operation. Put your specifications in the hands of crane craftsmen who minimize cost yet retain quality with superior performance.

LET PACECO BID YOUR NEXT MILL CRANE
Contact your nearest PACECO office or write for brochure 4-D now.

PACECO
"TAILORS OF STEEL"

PACIFIC COAST ENGINEERING CO.

Alameda, California
P.O. Drawer "E"
LAkehurst 2-6100

Torrance, California
(Los Angeles Area)
FAirfax 0-0341
Los Angeles—SPruce 5-1089

New York, New York
51 East 42nd Street
OXford 7-1475

REPRESENTATIVE:
Houston 1, Texas
P.O. Box 1035
MOhawk 4-3504

ALLIS-CHALMERS . . . in step with **STEEL**

Batteries of high speed electronic brains in Allis-Chalmers computing laboratory are helping answer a major problem facing all steel mills.

Computers Cut Shakedown Time

In the past a major cost factor of new motor and control has been the weeks of shakedown time required before operating at full production.

Typical problems solved before the rolls start turning are:

1. Analyzing electric drive for stability—ability to recover or settle out.
2. Computing values needed to set voltage regulators.

Solutions to problems are frequently designed into the equipment. Motor characteristics are established by the computer and regulators are coordinated with it.

Talk over your control and drive problems with Allis-Chalmers. Contact an A-C office or Allis-Chalmers, Milwaukee 1, Wisconsin.

Plan to stay ahead... MODERNIZE!

ALLIS-CHALMERS A-C A-5965-1S

NEW WELDCO Pipe Testing Machine

WELDCO Installation in the St. Henry Works of The Steel Co. of Canada, Ltd.

WELDCO Automatic Pipe Testing Machines test up io 1,000 pieces of pipe per hour . . . 1/2" through 6" up to 50 ft. lengths.

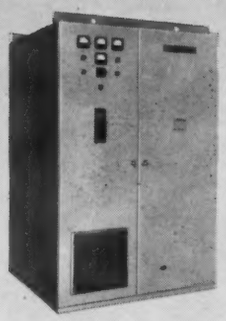
- Fully automatic on uniform lengths—one man operated.
- Maximum test pressure up to 5,000 psi.
- Low initial cost.
- Controls are all on one panel—for convenient, fast operation.
- Easy manual adjustment for random lengths—in a matter of seconds!
- Advanced design . . . for low-cost maintenance and trouble-free operation.

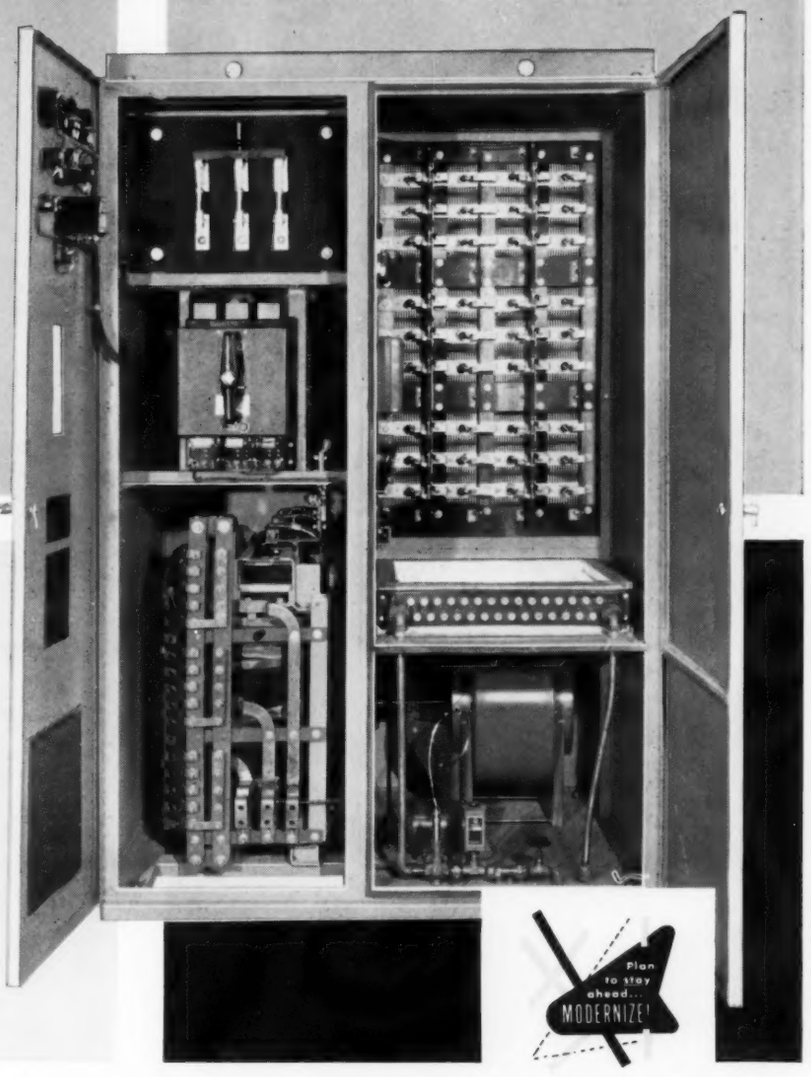
It will pay you to get the rest of the story. Just phone or write us today.

WELDCO

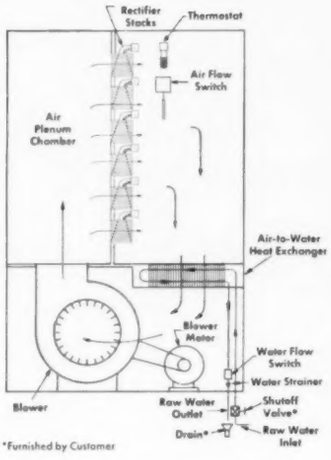
THE YOUNGSTOWN WELDING & ENGINEERING CO.
3724 OAKWOOD AVE. . YOUNGSTOWN 9, OHIO

ALLIS-CHALMERS...in step with **STEEL**

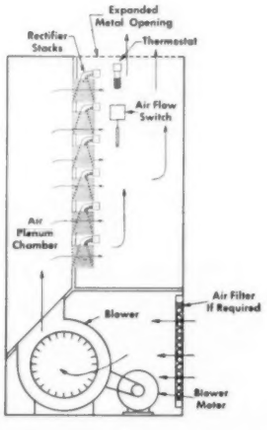




CHOICE OF COOLING SYSTEMS



A recirculating air system featuring an air-to-water heat exchange is employed where atmosphere is corrosive or dusty.



A simple air-cooling method is recommended for use in near normal atmospheres and where water is not available.

CORRECT APPLICATION

is the key to semi-conductor rectifier efficiency in the steel industry

Sure, you're looking for the high conversion efficiency, low maintenance and simplified operation associated with semi-conductor rectifiers. And you'll get all these advantages — and more — if the semi-conductor rectifier is a right-for-the-job installation.

Your local Allis-Chalmers man will be glad to tell you whether *or not* a semi-conductor rectifier is best for your specific steel industry operation. He can afford to be completely unbiased in his approach to your problem because Allis-Chalmers makes *all types* of power rectifiers. At his disposal, and yours, are vast research and engineering facilities. Behind his recommendation is the world of assurance found in the fact that Allis-Chalmers has been developing, building and applying rectifiers in the steel industry for almost 25 years.

For complete information, call your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. In Canada, write Canadian Allis-Chalmers Ltd., Box 37, Montreal, Quebec.

A-5950-15 **ALLIS-CHALMERS**

For a money-saving balance

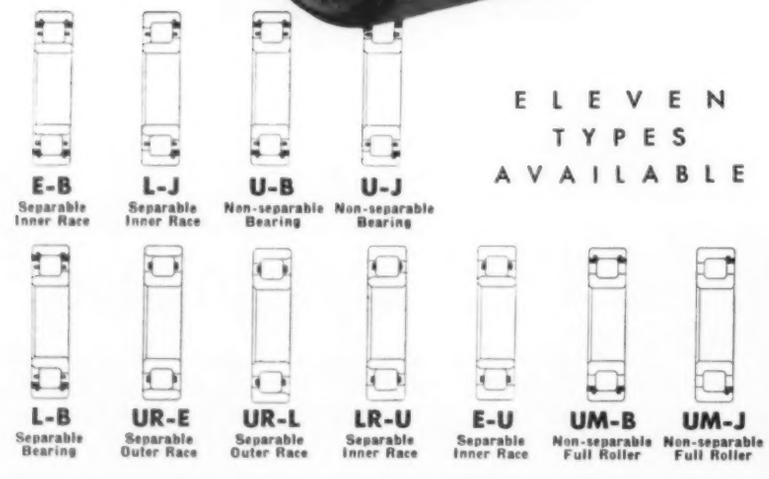
between maximum performance and moderate cost . . .

ROLLWAY Tru-Rol® BEARINGS

Give you more for your bearing dollar

For those hundreds of in-between applications where performance requirements are more exacting than those provided by the ordinary commercial bearing, but where maximum precision would be unneeded precision – specify Tru-Rol for the job.

Tru-Rol Bearings provide above-commercial-grade efficiency . . . at worthwhile savings in cost. Internal clearances are closely controlled. Rollers are equally spaced to eliminate out-of-balance vibration. Each roller is crowned to distribute the load evenly along the full length of the roller. Eleven types available in single and double width bearings, in stamped steel retainer, segmented retainer or full roller construction.



ELEVEN TYPES AVAILABLE

Ask your nearby Rollway Service Engineer to detail the quality you *should be getting* in your "commercial grade" bearings. Or write for the Rollway Tru-Rol catalog showing the full line, and capacity and size ranges. ROLLWAY BEARING COMPANY, INC., Syracuse, N. Y.

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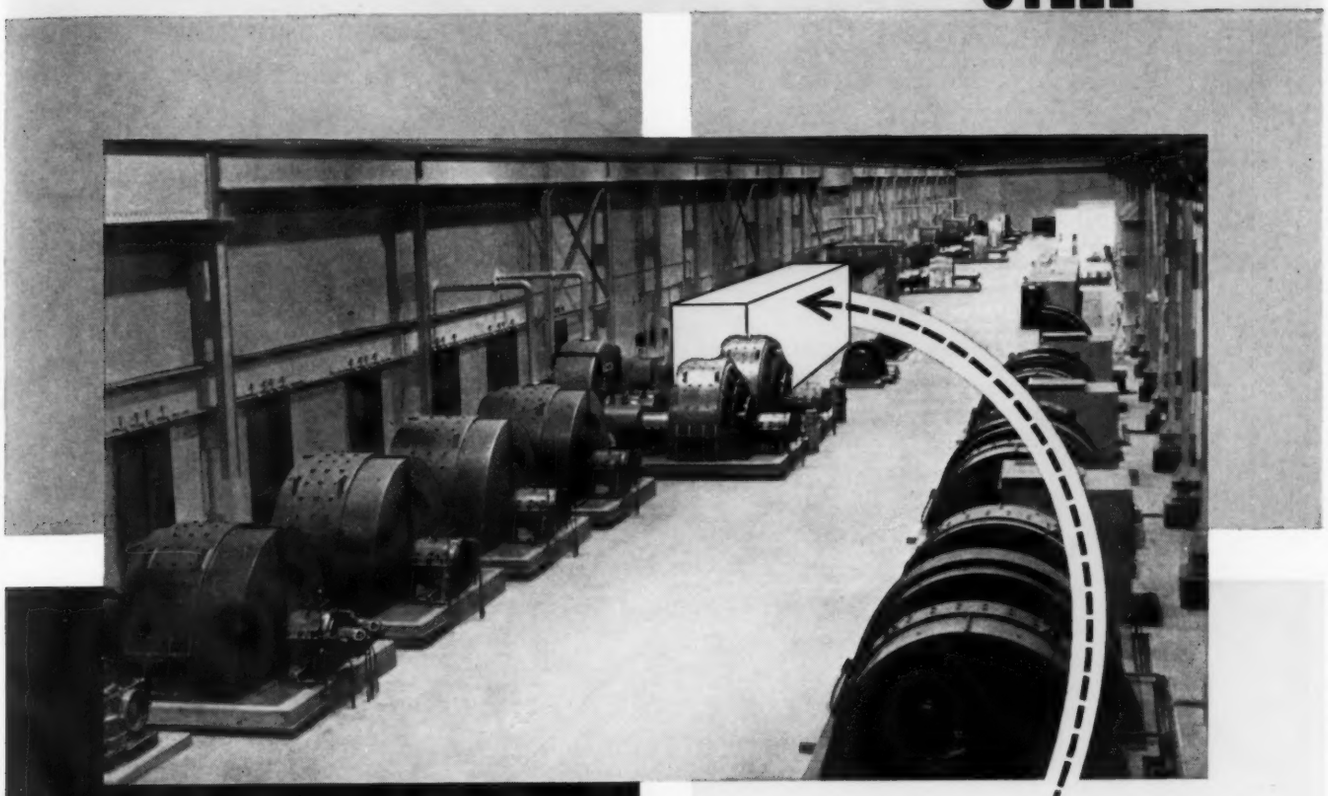
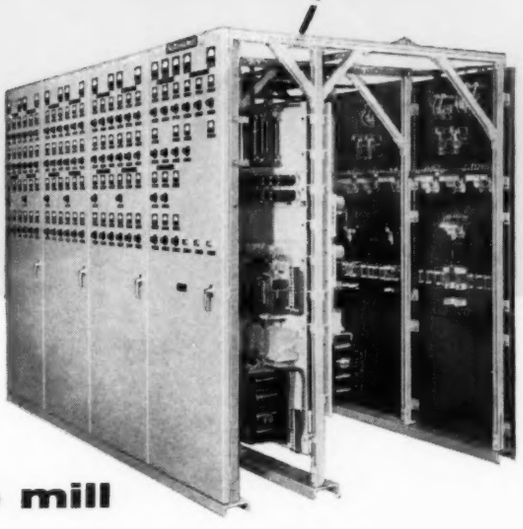
ALLIS-CHALMERS . . . in step with **STEEL**





NEW

Regulators modernize mill

Yield has been increased . . . scrap decreased as width and thickness of strip are held to closer tolerances.

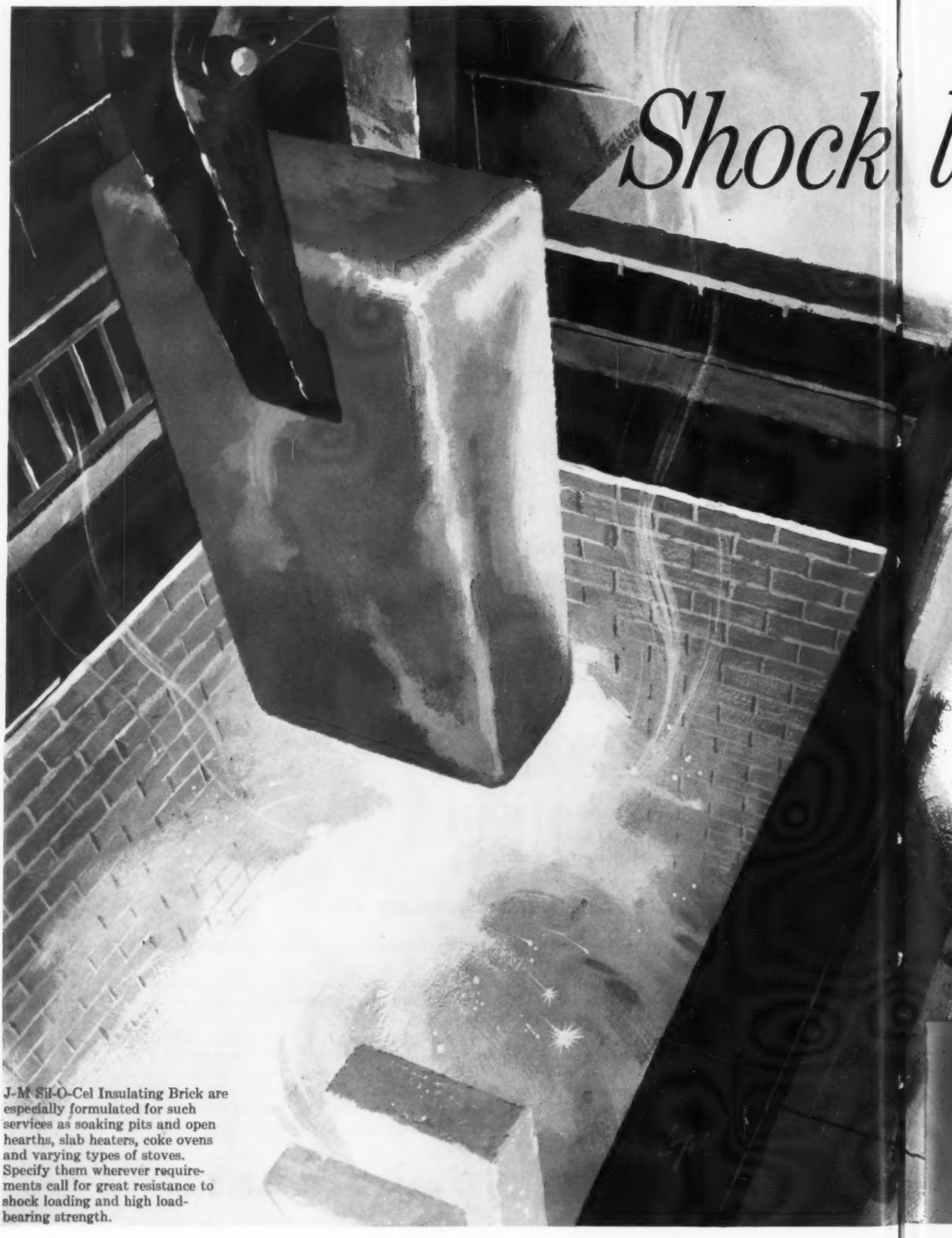
Nothing was changed except the control in this large eastern mill. The motor room of this 68-inch hot-strip mill looks practically the same as it did five years ago, but it's all new in operation.

New Allis-Chalmers stand speed regulators and bus voltage regulators featuring magnetic amplifiers make the difference. They were specifically engineered to provide a high gain, fast response system for consistent performance of the mill so that more high-quality product can be rolled.

Find out what modern control can do for your operations. Contact your nearby A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

A-5964-1S



J-M Sil-O-Cel Insulating Brick are especially formulated for such services as soaking pits and open hearths, slab heaters, coke ovens and varying types of stoves. Specify them wherever requirements call for great resistance to shock loading and high load-bearing strength.

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call for Johns-Manville Sil-O-Cel Insulating Brick!

Hot blast stove walls, open hearths, soaking pit bottoms—the unexcelled performance of J-M Sil-O-Cel® brick in rugged services like these explains their wide acceptance. Today, they are used as back-up insulation by virtually every major equipment builder.

Made of heat-resistant diatomaceous silica, Sil-O-Cel Insulating Brick are produced in three load-bearing types: Sil-O-Cel *Super* (to 2500F) and Sil-O-Cel *C-22* (to 2000F) for peak performance and long life under extremes of heat, weight and shock. Sil-O-Cel *16L* combines performance and economy for lower temperatures to 1600F.

To bring you the right brick for your needs, Johns-Manville *also* offers six Insulating Fire Brick types. This wide selection of Insulating Fire Brick lets you choose the *one* brick that gives you the most favorable combination of temperature resistance, strength, conductivity, density and cost.

Write today for your copy of IN-115A, 8-page booklet on Johns-Manville Insulating Fire Brick. It gives complete physical and thermal properties of each type, along with sizes and shapes available. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

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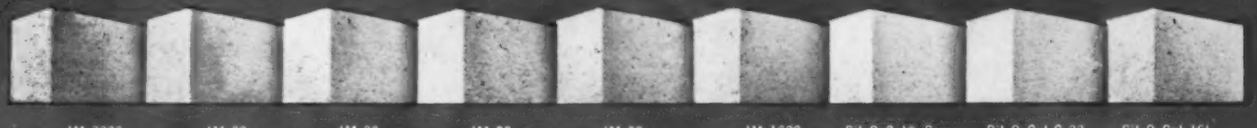

JM-3000 service to 3000F | JM-28 service to 2800F | JM-26 service to 2600F | JM-23 service to 2300F | JM-20 service to 2000F | JM-1620 to 1600F exposed; to 2000F back-up | Sil-O-Cel® Super to 2500F back-up | Sil-O-Cel C-22 to 2000F back-up | Sil-O-Cel 16L to 1600F exposed or back-up

experience

Alertness to individual operating requirements, coupled with a broad knowledge of rolling practices, is a major part of every Blaw-Knox Roll Engineer's experience.

Behind him is an organization with more than a century's experience in the development and manufacture of rolls.

This experience is your assurance of rolls having the properties, dimensions, and finish for maximum service.

Blaw-Knox Roll Engineers welcome the opportunity to join with you in selecting and applying the rolls best suited to your operating conditions.

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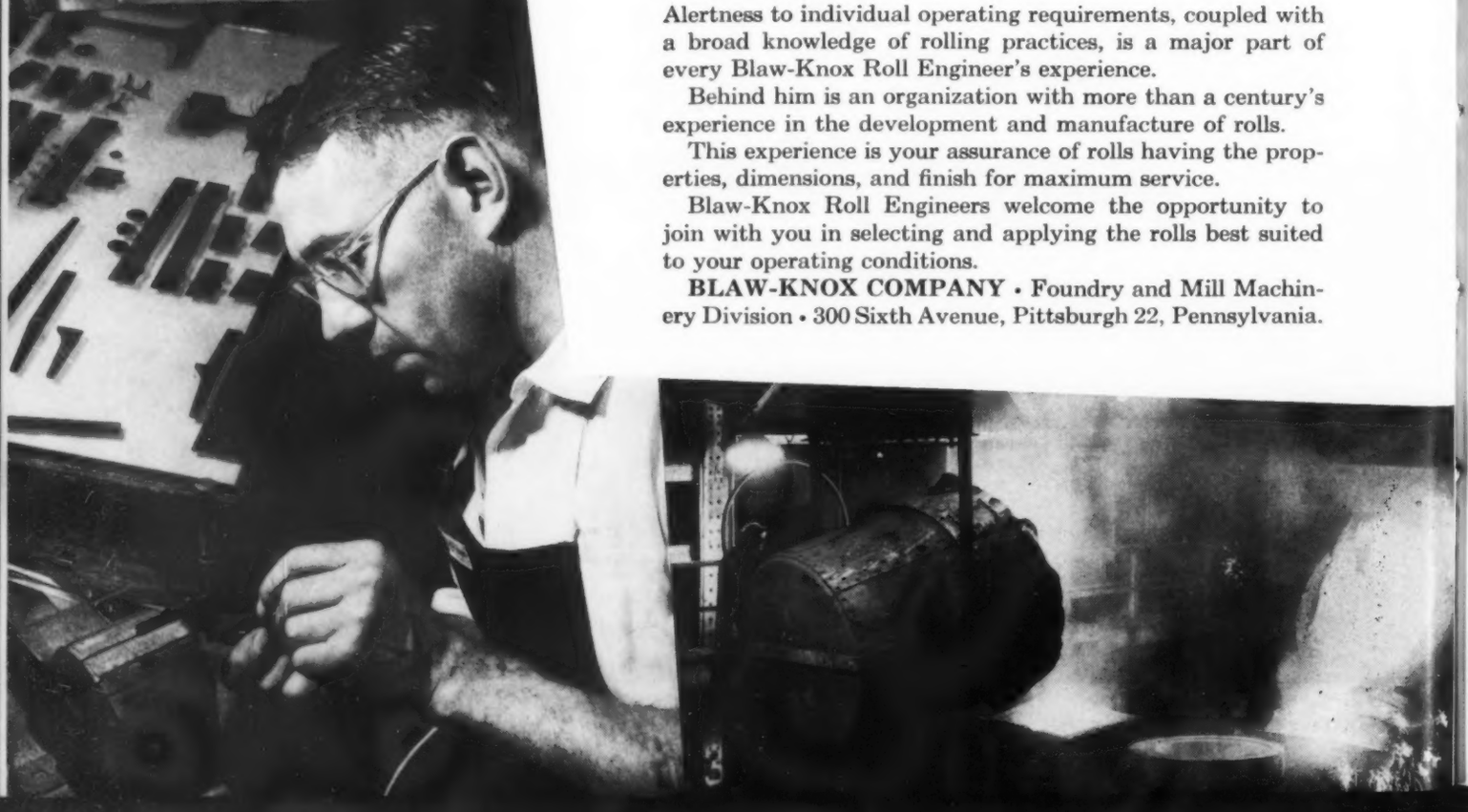

Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"CHANGES IN BLAST-FURNACE PROCESS WHEN WORKING ON FLUXED SINTER"

by N. N. BABARYKIN and F. A. YUSHIN, Magnitogorsk Metallurgical Combine. (Translation No. 4500 from Stal, Vol. 18, 1958, No. 12)

Δ THE investigations were carried out on blast furnaces A, B and C at Magnitogorsk with working volumes of 41,600 and 48,300 cu ft. The ore in the burden included fluxed sinter from two plants (from a mixture of sulphide and oxide ores, and only from sulphide ores) and iron ore; containing, respectively, 51.2 to 51.8, 54.5 to 55.1 and 55.0 to 58.0 per cent of iron. The mean ferrous oxide content in the sinter varied, in the various periods studied, from 15 to 18 per cent, the basicity (lime/silica) from 1.40 to 1.46, and the reducibility index (determined by the MMK method) from 45 to 48 per cent. Limestone was introduced only to control the slag composition, and no manganese or metal additions were made.

All the furnaces worked smoothly and were in a satisfactory condition. During the study, furnace B had a record output and a record coke rate for large-volume furnaces.

Samples were taken, temperatures and gas compositions at the second and third levels determined, and measurements with a probe thermocouple were made on furnace B, while at furnace A the composition of the materials and gases along the radius of the bosh were studied, and in furnace C, the composition of the stock and the temperature of the gases in the upper part of the shaft and in the hearth.

SUMMARY

The greatest radial nonuniformity of reduction of iron oxides is found in the upper shaft; as the stock descends to the lower levels this nonuniformity decreases.

The mean degree of reduction of iron oxides at four levels from just below the stock line down is, in per cent, 22.6, 32.5, 57.6, and 85.7.

Intensification of reduction in the medium temperature zone improves considerably the working of a blast furnace.

Analysis of the variations of sulphur content at the various levels confirms the theory that it circulates in the lower part of the stock column.

The temperature range in which fluxed sinter becomes pasty narrows as the degree of reduction of iron oxides increases.

To secure smooth and steady working of a furnace, the zone of stock softening, creating an additional resistance to gas passage, should be kept in the bosh or the lower shaft.

Formation of drops of liquid phase is preceded by the gradual separation of metal from slag inside the lumps of sinter.

With well-prepared burden, the ferrous oxide content in the primary slag is low and does not prevent any driving of the furnace.

The presence of liquid slag in the mass of "dry" materials is explained, apparently, by its transport from lower levels, and also by the considerable difference in physical heating levels of lumps of dissimilar chemical preparation.

The maximum temperature of the gas in the tuyere zone (about 3615 F) is at 15.75 in. from the tuyere nozzle.

In the combustion zone, there is partial elimination of sulphur from metal and slag.

Most of the metal and slag drips into the hearth around a peripheral annulus extending not more than 6½ ft inward from the furnace wall.

"CONTROL MEASUREMENTS IN DEGASSING OF LIQUID STEEL IN VACUUM"

by K. BROTZMANN, K. RUTTIGER, K. FORSTER, and R. HENTRICH. (Translation No. 4601 from Stahl und Eisen, vol. 79, 1959 No. 7)

Δ FOR reliable control of vacuum degassing of steel melts, it is

essential to provide adequate control and supervision by measuring the processes taking place. The quantities which can be measured are as follows:

1. Quantity, pressure and composition of extracted gas.
2. Amount of steel sucked up into the degassing vessel at each lift. This is measured from the height of the surface of the metal in the ladle and the position of the degassing vessel.

The information which can be obtained from the measured values is as follows:

3. Oxygen and hydrogen contents of steel in the degassing vessel and ladle.
4. Information as to the extent to which steel flowing back into the ladle from the degassing vessel and steel already in the ladle are mixed.
5. Amount of steel passing through the suction pipe of the degassing vessel.
6. The transport forces necessary for the flow.

The amount of gas removed is measured with a gas meter or by measurement of the pressure of the gas extracted and the suction capacity of the pumps, taking into consideration the temperature of the gas. The pressure of the drawn-off gas is plotted with the usual pressure recording devices. The composition of the gas is determined by means of an analyzer which measures carbon monoxide, carbon dioxide and hydrogen contents of the gas continuously.

The amount of steel in the degassing vessel and the throughput of steel through the degassing vessel can easily be measured, since the degassing vessel is filled and emptied periodically. Since it is difficult to make a direct measurement of the amount of steel in the degassing vessel, the amount of steel drawn from the ladle through the suction pipe is measured instead. This quantity is obtained from the drop in the level of the metal in the ladle and the cross-sectional area of the ladle.

Extractable oxygen content can be calculated from the separate portions of steel flowing into the degassing vessel and from the quantity and composition of the gas which has been drawn off. This extracted oxygen content, plus a residual content which is not extracted, gives the initial oxygen content of the quantity of steel drawn into the vessel each time.

Experience has shown the residual content of free oxygen to be about 0.002 per cent. In the case of heats partially deoxidized before treatment, the residual content is increased by the amount of oxygen combined with the deoxidation products that remained in the steel and were not reduced during the short period of vacuum treatment.

For determination of hydrogen content of the melt, it is convenient to proceed along the same lines as in determining the oxygen content. The hydrogen released by the steel in a single lift is measured from the volume and composition of the gas. The quantity of hydrogen divided by the amount of steel lifted gives the content of hydrogen of this particular portion of steel. Unfortunately, this procedure is not as accurate as in the case of oxygen, since residual hydrogen which remains in the steel is of the same order of magnitude as the proportions extracted.

"BOILING OF UNKILLED LOW-CARBON STEEL UNDER VACUUM"

by G. HENKE and W. HESS. (Translation No. 4599 from Stahl und Eisen, vol. 79, 1959, No. 7)

△ THE Hoesch-Westfalen plant experimented with a process in which unkilled, bottom poured, low-carbon steel is allowed to "boil out" in the mold and solidify to a considerable extent under vacuum. After preliminary trials with single bottom poured ingots and units consisting of two bottom poured ingots, this practice was carried out with groups of four bottom poured 8.25 net ton slab ingots. The cold-rolled strip produced from these ingots, when subjected to ultrasonic testing, exhibited a freedom from slag normally associated with top pouring while the freedom from slag of the steel corresponding to the bottom of the ingot exceeded that normally associated with top pouring.

After aluminum had been added to combine with the residual oxygen, segregation in the ingot core is much less than that of the untreated steel so that cropping of the rolled product is no longer required. There is also an absolute decrease of the sulphur dissolved in the steel and, to a lesser extent, of the phosphorus. The deep drawing characteristics of the cold-rolled strip are improved by this process, particularly the uniformity.

OTHER AVAILABLE TRANSLATIONS

"**Rapid Analysis of Ores and Similar Materials**" by A. Neuberger, et al. Archin Eisenhüttenwesen, vol. 29, 1958, No. 9. Rapid procedures for photometric determination of iron, manganese, silicon dioxide, phosphorus, calcium oxide, magnesium oxide, aluminum oxide, and titanium dioxide, also copper, chromium, and lead in ores and similar substances, from the same sample, after decomposition with borax. Accuracy of results; times required for the various procedures. *Appendix*—Official report by the Committee on Chemical Analysis of the VDEh on the merits of the proposed procedures. (Translation No. 4501)

"**Stream Degassing of Unkilled Low-Carbon Steel,**" by H. Hoff, H.-J. Kopineck and G. Opfer, Stahl und Eisen, vol. 79, 1959, No. 7. Requirements to be met by a vacuum-treating process for large-tonnage steel: (a) pouring directly from ladle into ingot mold; (b) shortest possible travel of steel under vacuum; (c) collection of degassed droplets into a dense stream before entering the mold. Description of an experimental setup for stream degassing of either top- or bottom-poured low-carbon steel. Details on pilot plant set up at the Hoesch-Westfalen works, using a steam ejector as vacuum pump. Results obtained: ingots free from pipe and rimholes; best surface quality; absence of nonmetallic inclusions according to ultrasonic tests. Sulphur prints from stream-degassed vs conventionally poured slabs. Mechanical properties of cold-rolled strip; possibility of making it aging-resistant by making slight additions of aluminum to the degassed metal. (Translation No. 4600)

Where **ACME STEEL** Has Placed Complete Reliance on the Unique Gas-Cleaning "Know-How" of

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Virtually every major steel company across the nation has Western Precipitation equipment of one type or another handling gas cleaning operations from various types of steel-making applications.

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A DRY-TYPE PRECIPITATOR, known as a Western Precipitation Cottrell Unit, is installed on the Basic Oxygen Converters to provide final clean-up of gases before they are discharged to atmosphere.

Hot Blast Cupolas

"MULTICLONE" COLLECTORS, Western Precipitation's highly efficient small-tube collectors, are used for first stage cleaning of cupola gases.

Hot Blast Cupolas

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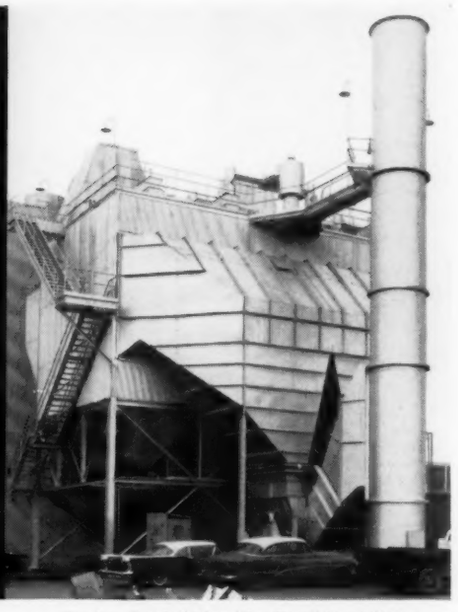
Western Precipitation "Wet Type" Precipitator



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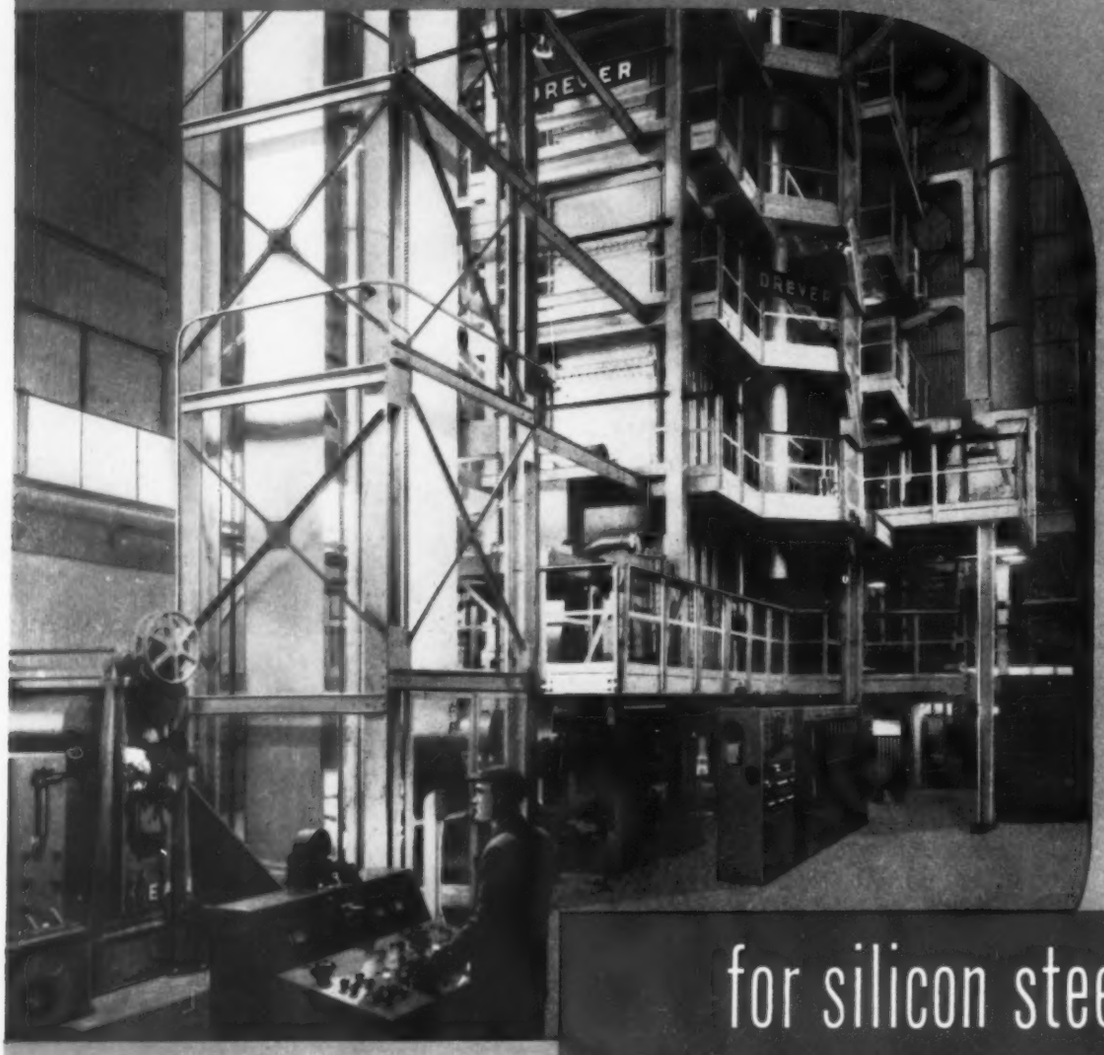
DREVER Continuous Strip Annealing Furnace Line



for silicon steel

Delivery end of Drever gas-fired radiant tube heated vertical annealing furnace for silicon steel strip installed at Empire Steel Corporation, Mansfield, Ohio.

This furnace was designed and installed by the Drever Company to produce 8 tons per hour of silicon steel strip. The heating and soaking zones are gas-fired radiant tube heated; the tubes having a connected load of 13,500 CFH of natural gas.

The furnace has been engineered to handle silicon steel strip in thicknesses from 0.017" to 0.025", in widths from 24" to 42", and for speeds from 60 to 180 FPM.

Drever continuous annealing lines for Tin Plate, Galvanized Stock, other Low Carbon Steel and Non-Ferrous Strip in capacities up to 30 tons per hour, provide an economical investment in tonnage production of quality material.

DREVER COMPANY

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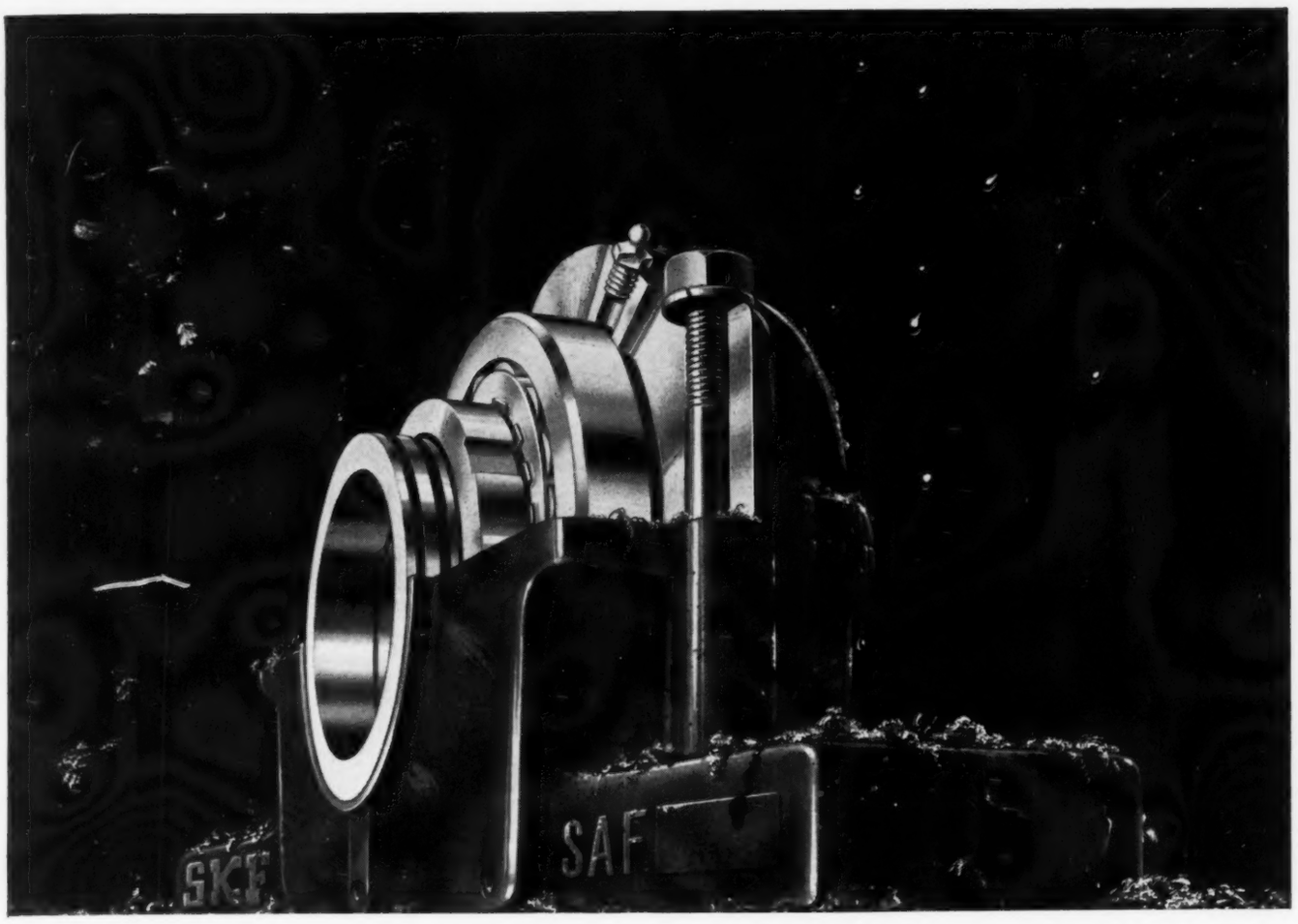


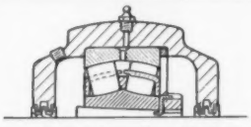
SKF Triple Seal
provides best possible protection

The SKF Triple Seal is a heavy duty, general purpose seal designed for use with oil or grease lubrication. It was developed by SKF to protect the bearing from foreign materials while providing an effective barrier against lubricant leakage.

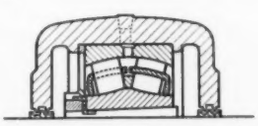
The bearings in all SKF split pillow blocks are protected by triple seal rotating rings. The seals are triple lipped and are one integral unit. They are mounted with a slip fit on the shaft which permits unrestricted axial motion. Being of the labyrinth type, there is no friction between the rotating and stationary components; consequently, there is no wear and no replacement problem.

SKF Triple Seal Type SAF pillow blocks, with ball or roller bearings, give long trouble-free service. If your design involves abnormal operating conditions, cast steel housings (designated SAFS and SDAFS) are available. These heavy-duty pillow blocks are recommended for use in oil field machinery, steel and rubber mills, crushers, etc.

Standard type SAF split pillow blocks are available for ¾" to 10½" dia. shafts, and Type SDAF for 2 11/16" to 14" in adapter type mounting. Direct shaft mounting available for shaft shoulders up to 9 7/16" and shaft extensions up to 8 5/16". For data on both designs, send for Catalog 390.



SAF medium-duty pillow blocks contain the new SKF spherical roller bearings which offer 25 to 50% increased capacity, 2 to 3½ times longer life.



SDAF pillow blocks are designed for heavy-duty applications and also contain the new SKF spherical roller bearings.

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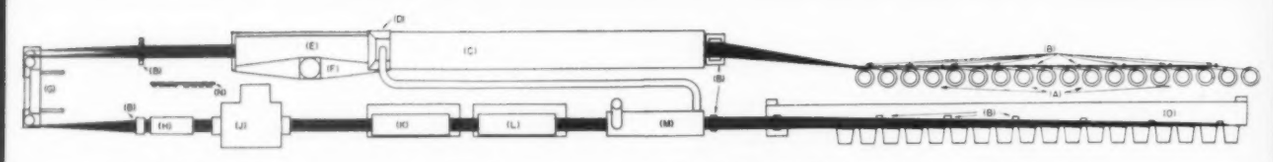

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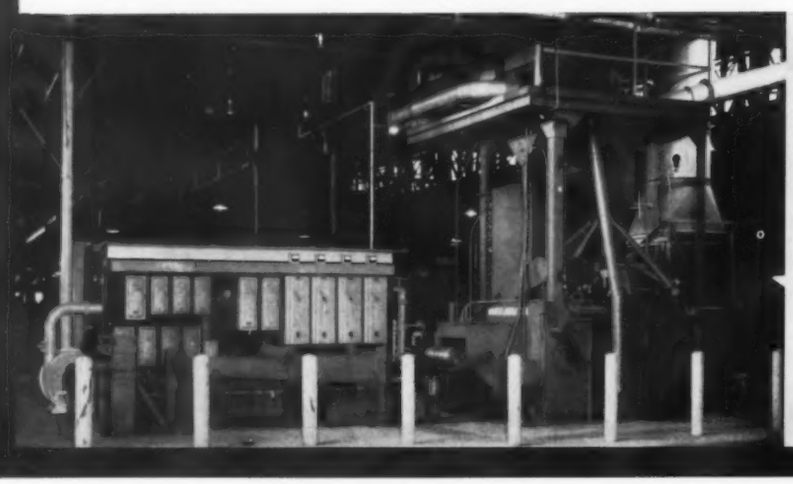
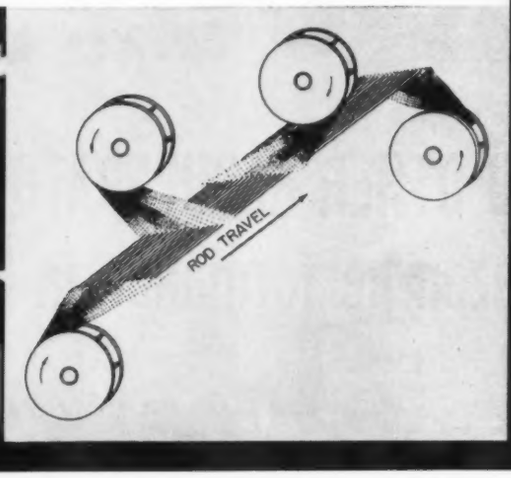




ROEBLING continuous wire production based on WHEELABRATOR® blast cleaning

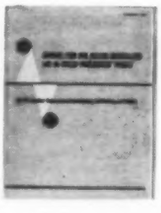
Continuous patenting, cleaning and coating of steel wire adds up to more efficient operation at lower cost, for John A. Roebling's Sons Corp.

The new processing line, installed at the Roebling mill, incorporates Wheelabrator airless blast cleaning as a key step in the operation. Wire now is patented and cleaned in one continuous operation, with a resultant decrease in labor cost.

Eighteen strands of steel wire pass simultaneously through the muffle furnace, lead quenching bath, Wheelabrator blast cleaning machine, coating baths, drying ovens, and thence to the take-up frame, in a compact operation occupying an area of 250 ft. long and 30 ft. wide. Normal production rate is about 6,000 pounds per hour. Speeds through the blast cleaning unit vary with the gauge of wire, with .250" diameter rod running at 34 fpm.

Wheelabrator mechanical cleaning eliminates the costly problems of acid disposal, and maintenance of acid pickling equipment. By promoting efficient "straight-line" production, it minimizes handling costs. The combined effect of cleaning and labor savings is a considerable reduction in the patenting and cleaning cost.

Write for Bulletin 148-D, illustrating use of the Wheelabrator process for producing finished wire from hot rolled rod in one continuous operation.



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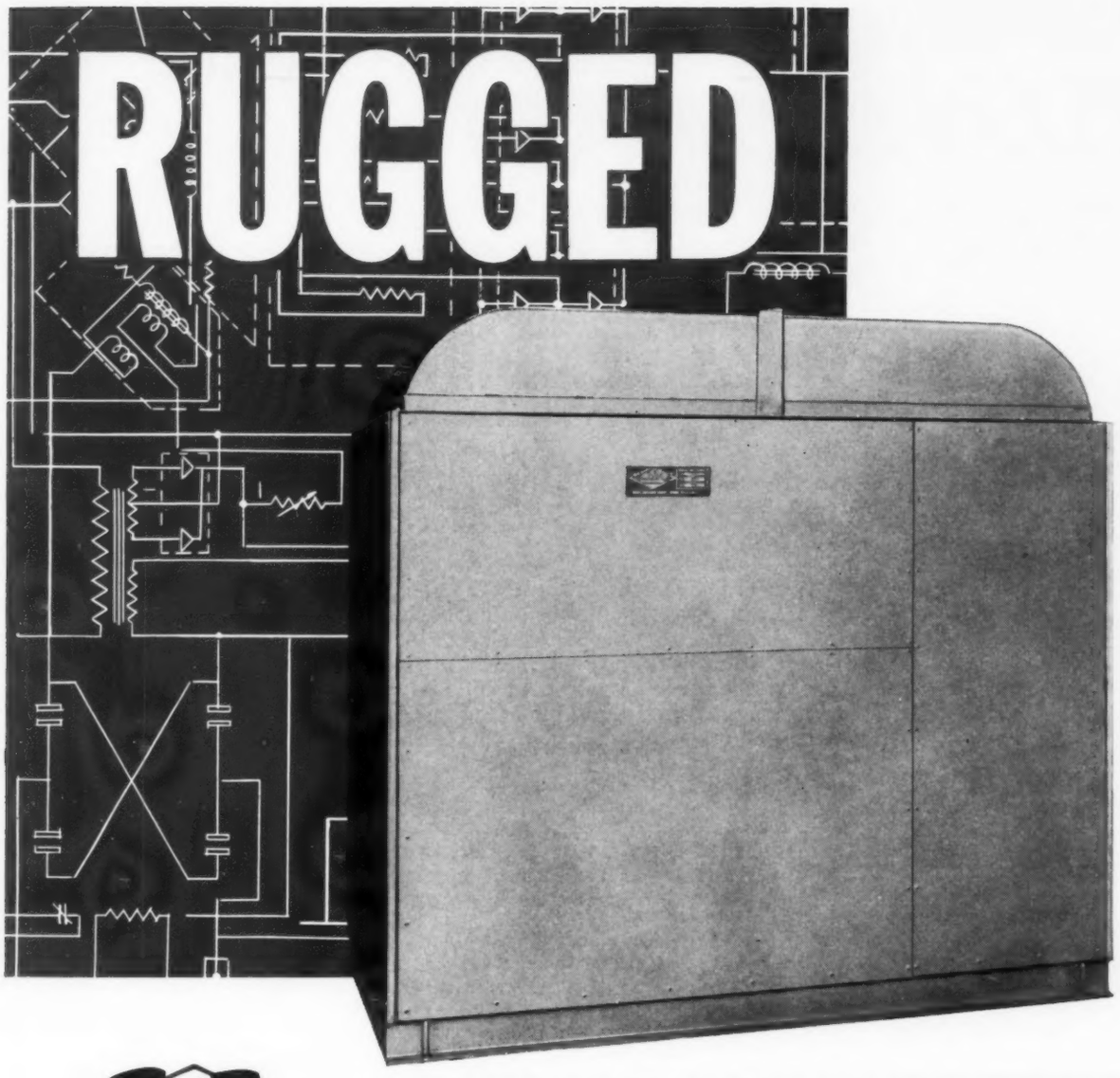

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Underwater for three days during a recent New England flood,* two Sel-Rex Rectifiers operated perfectly after a superficial cleaning. Now we don't recommend running Sel-Rex Rectifiers underwater—but this incident typifies the rugged dependability you get with all Sel-Rex Metallic Power Rectifier Equipment.

Our fully illustrated "GUIDE" to METALLIC POWER RECTIFIERS gives details on semiconductor power conversion equipment and full systems for most industrial AC to DC applications. Whether your interest is practical or academic, this "GUIDE" will become your most dependable source of DC power information. Please request your FREE copy on your company letterhead.

*We do make a model for underwater operation.

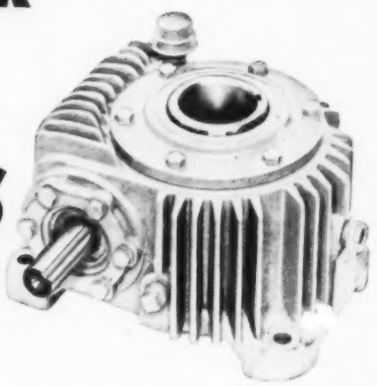
Rectifier Division

SEL-REX CORPORATION

Nutley 10, New Jersey

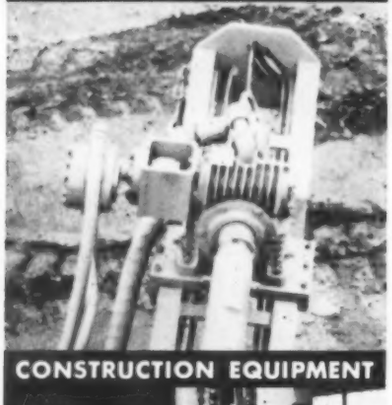
"Complete Semiconductor Power Conversion Systems for any AC to DC application."

CONE-DRIVE WORM GEAR HOLLOW SHAFT SPEED REDUCERS

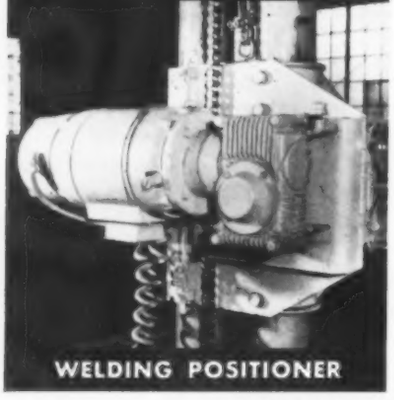


provide greater flexibility in the design of your equipment

MIXING MACHINE



CONSTRUCTION EQUIPMENT



WELDING POSITIONER

Standard Cone-Drive hollow shaft speed reducers are available in four basic sizes (2, 2½, 3 and 3½ inch center distance units) to accommodate loads from fractional to 13 horsepower. They are built around the double-enveloping worm gear design and carry the same high ratings as standard Cone-Drive speed reducers.

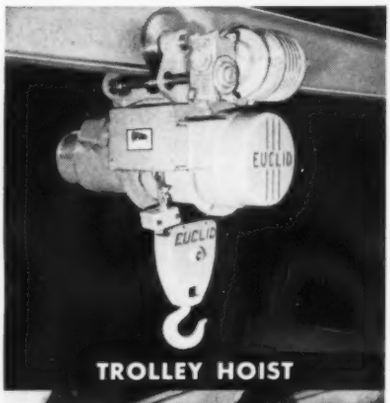
You, as a designer, will be particularly interested in the versatility of application and space savings made possible by the right angle design between input and output shafts.

The reducer is mounted directly on the driven shaft and requires only a simple bracket or torque arm to prevent it from rotating about the driven shaft.

Construction is rugged enough to permit floor or wall mounting of Cone-Drive hollow shaft reducers and "hanging" the driven shaft on it (in certain applications), eliminating pillow blocks or bearings. Larger-than-necessary taper roller bearings and heavy-duty castings make this possible.

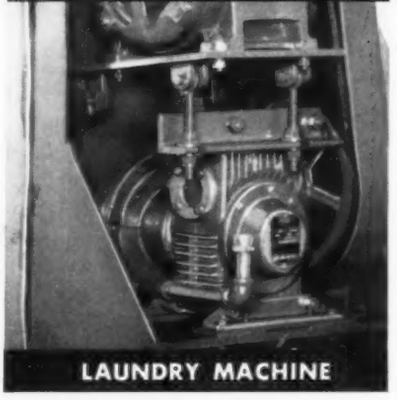
If a motorized reducer is desired, a simple, standard bell housing can be furnished for NEMA C-type face motors. The need for expensive couplings is eliminated since a tang-type drive sleeve and suitably machined worms are provided. When a hollow-shaft speed reducer and face-mounted motor are combined, no bed plate or mounting arrangement is required. Pulleys, belts, sheaves, etc., that might be troublesome or difficult to install are also eliminated.

Ask for Bulletin CD-218.



TROLLEY HOIST

MILL ROLL DRIVE



LAUNDRY MACHINE

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

The industry and Aetna's engineers work together in developing new ideas on seamless. Here is part of the new Aetna-built Seamless Mill of The Youngstown Sheet & Tube Co. at Indiana Harbor.

Seamless Pipe and Tube Mills

Most of the ideas about making seamless have been worked out between the producers and Aetna-Standard in their more than fifty years of association. Known as the "pipe mill people", Aetna has built most of the Seamless Mills in this country and around the world.

Aetna designs and builds several basic types of Seamless Mills. The Plug Mill or Two-High Rolling Mill is most generally used for the production of all sizes of seamless pipe and tubing. The Mandrel-Type Continuous Rolling Mill features high-volume production of small- and medium-sized tubing. The Assel Mill produces high-quality tubing to close tolerances, as required for anti-friction bearings and mechanical tubing.

In combination with the basic Plug Mill or Mandrel Mill, Aetna builds the Stretch Reducing Mill. This unit has the advantage of economical production of small-sized tubing at maximum volume, while maintaining the high tonnage production of the basic Seamless Tube Mill. Another type—the Rotary Pipe Expander—produces pipe of larger diameters than can economically be produced on the Plug Mill.

BLAW-KNOX

BLAW-KNOX COMPANY

Aetna-Standard Division

Frick Bldg., Pittsburgh, Pa.

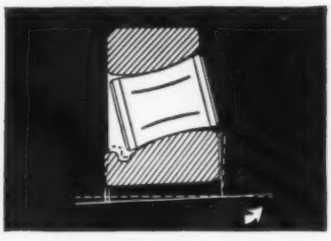
the PLUS values in SHAFER ROLLER BEARINGS

LONGEST LIFE UNDER TOUGHEST CONDITIONS

With Shafer Self-Aligning Roller Bearings your equipment lasts longer under tough conditions that usually spell early trouble.

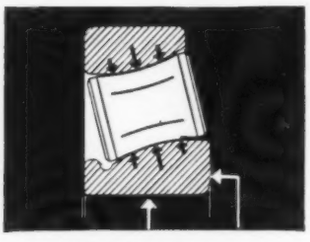
You eliminate many hours of costly down time and keep maintenance costs at a minimum... you get the very best in dependable service.

The reason: Shafer Self-Aligning Roller Bearings maintain their high load-carrying capacity and long life under any type of load. Here's why:



Shaft deflection

Under misalignment due to shaft deflection (a total of 3°), Shafer design allows full freedom of action without extra wear.

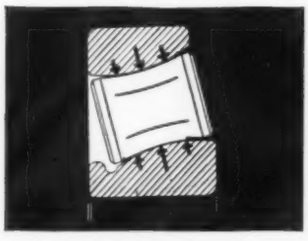


Radial, thrust or combined loads

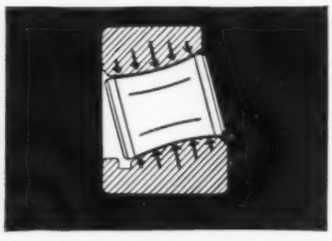
Due to Shafer concave-roller, convex-race design, all loads remain safely centered on tough load-bearing surfaces. Because of self-centering rollers, there's no need for guide flanges at roller ends.

Shock Loads

Shafer design combines the low-rolling friction of a ball with the high load and shock capacity of a roller. The elasticity of Shafer rollers and raceways permits compression under shock. The contact area increases to fit the load-bearing area to the load requirement.



Under Normal Load



Under Heavy Load and Shock

Pillow Blocks

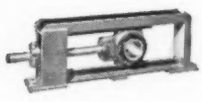
Flange Units

Flange Cartridge Units

Cartridge Units

Duplex Units

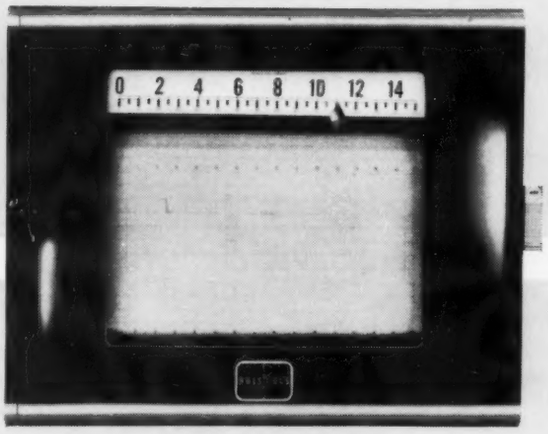
Take-Up Blocks



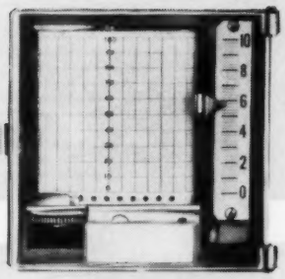
Take-Ups

SHAFER®
SELF-ALIGNING ROLLER BEARINGS

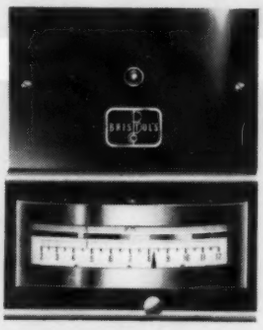
For complete information on the plus advantages of Shafer Bearings, see your distributor or write for your free copy of Bulletin 59A. CHAIN Belt Company, 4693 W. Greenfield Ave., Milwaukee 1, Wis. In Canada, write CHAIN Belt (Canada) Ltd., 1181 Sheppard Ave., East, Toronto.



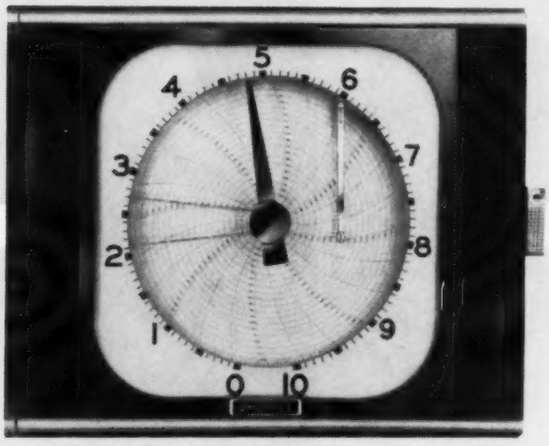
Dynamaster Electronic Potentiometer Pyrometer—Strip-chart model records on chart 11" wide, 120' long.



Miniature Electronic Dynamaster Pyrometer—Records on 3" strip-chart. Indicator model features easy-to-read 9" scale length.



Bristol Millivoltmeter Pyrometers—Free Vane* pyrometer controllers (shown) or indicating types. Many control modes available.



Dynamaster Electronic Potentiometer Pyrometer—Round-chart model records on 12" chart, indicates on extra large scale.

MODERN PYROMETERS...key to profitable use of HEAT

Bristol recording and automatic controlling pyrometers for temperatures up to 5000°F can help you increase product uniformity, cut fuel and maintenance costs

Bristol makes a wide range of pyrometers for every requirement: Electronic potentiometers, millivoltmeter and radiation types . . . for furnaces, ovens . . . every type of heating equipment, every kind of fuel. The reliability and accuracy of these precision instruments have been proved in thousands of installations.

Take just one advanced Bristol instrument, for example, the Electronic Dynamaster* Potentiometer Pyrometer:

CONTINUOUS STANDARDIZATION PLUS ACCURACY OF STANDARD CELL

Continuous standardization in Dynamaster Electronic Pyrometers requires no dry-cells, **but still retains the precision standard cell for highest stability and accuracy of voltage reference.** Results: No interruption to operation, no batteries to change. And here are just a few of the Dynamaster types available:

A model for every requirement: Dynamaster Pyrometers are available as single-pen, two-pen, and multiple-record (up to 24 points) *strip-chart* instruments and as *round-chart* instruments.

Electric and pneumatic controllers: Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control—on-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control—on-off, proportional, and proportional with reset.

Miniature Dynamaster Pyrometer: Full plug-in flexibility . . . takes only 5" x 5⅛" of panel space, but has same basic accuracy, same time-tested operating principle as full-size Dynamaster pyrometers described above. Ideal for graphic panels and centralized recording or indicating of large numbers of variables. Either electrical or pneumatic control types available.

Write for complete data on Bristol Pyrometers—and remember Bristol offers a complete line of thermocouples and pyrometer accessories. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn. **T.M. Reg. U.S. Pat. Off.* P.9

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

AIRCO
INDUSTRIAL
AND RARE
GASES

ARGON
OXYGEN
ACETYLENE
NITROGEN
NITROUS OXIDE
HYDROGEN
CARBON DIOXIDE
HELIUM
XENON
KRYPTON
NEON

1. HIGH S-W RATIO. One of the most efficient of modern structural forms is the lightweight honeycomb assembly—dubbed the sandwich panel. Typical is this one, designed for the supersonic B-58, and providing the strength of solid steel at less than half the weight. Here's how it's made—

PART OF THE PICTURE

when Twigg makes the remarkable sandwich panel . . .

AIRCO INDUSTRIAL GAS SERVICE

2. "FOILED" FOR SUCCESS. Twigg Industries produce the sandwich panel for Convair. It calls for the most modern, most skillfully applied brazing technique.

Over each face of this stainless steel honeycomb "core" technicians lay a paper-thin sheet of brazing alloy. And here Airco is part of the picture—as supplier of this vital silver-copper-lithium "foil," which must produce uniform, high-strength joints resistant to corrosion and extreme operating temperatures.

Next come the panel's stainless steel skin sheets.

3. IN THE BAG. Now chemically clean core, foil, skins, edge members and slugs are assembled and spot-tacked. Components pre-joined, the panel is weld-sealed within an airtight stainless steel bag.

At the purging station Airco again is part of the picture, supplying argon to replace the air in the bag.

4. BRAZED IN ARGON. Entire unit, now placed in a stainless steel retort in a furnace, is brazed for about 5 to 8 minutes at 1665°F. The atmospheres within both retort and envelope are purged continuously to maintain an environment of 100% Airco argon.

After the brazing cycle, the panel is chilled to −100°F with CO_2, reheated and X-rayed to make certain that fillets are completed and sound—an important step in the final checkout.

5. EVER-READY SUPPLY. From these Airco bulk trailers, argon and hydrogen are streamed directly into the Twigg brazing processes at Martinsville, Indiana.

More and more, the bulk trailers of Airco are part of today's industrial picture: they represent an economical way to assure an ever-ready supply of needed industrial gases.

Manufacturers in aircraft and missiles, steel, electronics, chemicals, food processing and many other industries rely on Airco for dependable supplies of high purity industrial gases.

Airco also supplies welding and cutting equipment and electrodes, and renders technical service covering all phases of gas and gas equipment applications.

Would you like to explore ways in which modern gas applications could improve your operation? Do you need a special grade of gas? Do you know how economical a permanent gas installation can be?

Call in your nearby Airco Engineering Service Representative. Airco backs him with unexcelled facilities.

AIRCO®

AIR REDUCTION SALES COMPANY

A Division of Air Reduction Company, Incorporated

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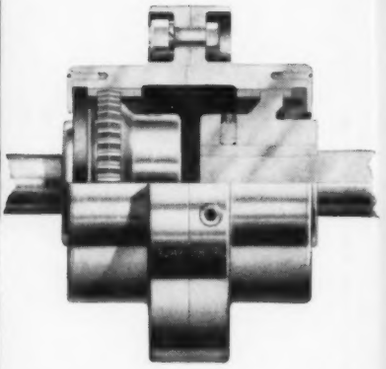
Offices and dealers in most principal cities • On the west coast—Air Reduction Pacific Company • Internationally—Airco Company International • In Cuba—Cuban Air Products Corporation • In Canada—Air Reduction Canada Limited • All divisions or subsidiaries of Air Reduction Company, Inc.

AT THE FRONTIERS OF PROGRESS YOU'LL FIND AN AIR REDUCTION PRODUCT • Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO**—Industrial gases, welding and cutting equipment • **AIRCO CHEMICAL**—vinyl acetate monomer, vinyl stearate, methyl butynol, methyl pentynol, and other acetylenic chemicals • **PURECO**—carbon dioxide—gaseous, welding grade CO_2, liquid, solid ("DRY-ICE") • **OHIO**—medical gases and hospital equipment • **NATIONAL CARBIDE**—pipeline acetylene and calcium carbide • **COLTON**—polyvinyl acetate, alcohols, and other synthetic resins.

AJAX DIHEDRAL Floating Shaft COUPLINGS



Cut-a-way view of an AJAX DIHEDRAL COUPLING shows arrangement of hub gears with AJAX patented Dihedral tooth shape.

AJAX DIHEDRAL GEAR COUPLINGS are made in a wide range of standard double engagement, floating shaft, mill motor and spindle types.

HANDLING HEAVY DUTY ANGULAR DRIVE FOR OVER 2 YEARS WITH ZERO MAINTENANCE COST

Photograph shows an Ajax Dihedral Floating Shaft Coupling which replaced an old style slipper joint used to handle the angular drive requirements between driving and driven units. This coupling has been in continuous operation for over two years with practically no maintenance cost as contrasted to the old style drive which had to be replaced every three to four weeks.

AJAX Dihedral Couplings give you mile-a-minute speed, smooth running constant peripheral velocity, freedom from backlash, close gauge tolerance, better surface finish, longer roll life, and far less down time.

Specially designed seals assure adequate lubrication, long life, reduced maintenance, and clean shop conditions.

Performance records of AJAX Dihedral Couplings are responsible for their being written into the specifications of the world's finest mills. Whether you are designing, building, buying or modernizing your mill, it will pay you to take advantage of the broad experience gained by AJAX engineers since their introduction of these radically improved Drives.

A reprint of a paper presented before the Association of Iron and Steel Engineers will give you authoritative information covering their contribution to mill performance. Consult the yellow pages of your phone book, or write for AJAX Bulletin 64.

AJAX®

AJAX FLEXIBLE COUPLING CO. INC.
204 Portage Road, Westfield, N. Y.

Please send latest AJAX Dihedral Spindle Coupling Bulletin No. 64.

Name _____

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OLIVE HILL

HIAC-K

SUPERAC-K

GENERAL REFRACTORIES

50 YEARS EXPERIENCE STAND BEHIND

GREFCO'S "BIG 3" STOVE BRICK!

For 50 years, General Refractories blast furnace stove brick have met the continuously tougher demands of American steelmaking. Here are today's "Big 3" in the GREFCO stove brick line, each made from the finest raw materials, under rigid quality control:

OLIVE HILL *Stove Wall Brick and* OLIVE HILL *Stove Checkers:* Preferred in hundreds of blast furnace stoves where high duty standard or multihole designs are used. Literally "a benchmark of the industry."

HIAC-K *Stove Wall Brick and* HIAC-K *Stove Checkers:* These super duty brick, standard or multihole, are made from specially calcined high-purity Georgia Kaolin, to provide low porosity and high density and refractoriness against severe service conditions.

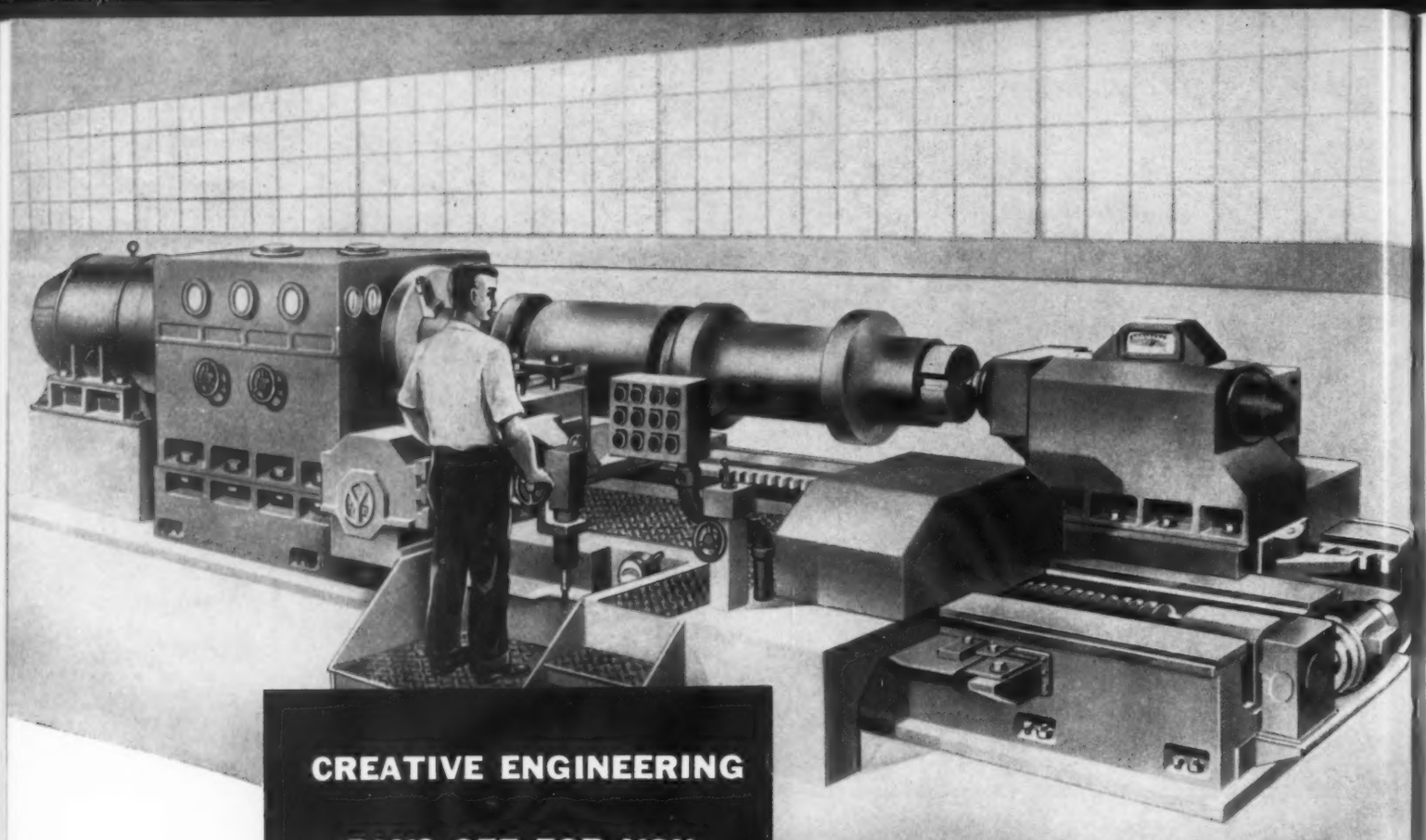
SUPERAC-K *Stove Wall Brick and* SUPERAC-K *Stove Checkers:* Designed to withstand the most extreme destructive conditions of modern blast furnace stoves, Superac-K are the latest improvements in high fired, superduty fireclay brick. Their exceptional purity, strength and refractoriness, coupled with unusually low porosity, make them highly resistant to prolonged temperature and alkali attack.

GREFCO manufactures a complete line of multihole and special stove checker designs in each of these leading brands. Your GREFCO representative welcomes the chance to talk to you about the particular GREFCO brick best suited to conditions in your blast furnace stoves. Call him.

GENERAL REFRACTORIES COMPANY

PHILADELPHIA 2, Pa.

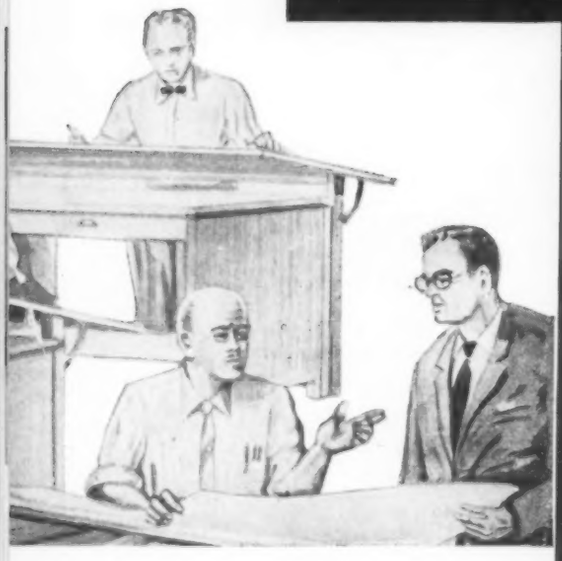
A COMPLETE REFRACTORIES SERVICE



CREATIVE ENGINEERING

PAYS OFF FOR YOU

AT "YOUNGSTOWN"



"YOUNGSTOWN" quality begins with the progressive ideas of our engineering staff (example: our new roll lathe design). Consult us . . . particularly on such completely integrated projects as pickling lines, scrubber lines, slitting lines, shearing lines, extrusion presses and auxiliaries, furnace charging equipment, runout tables . . . Paralloy and ductile iron rolls . . . Custom built equipment . . . all benefiting from our ¾ century of experience.

Automation hits peak in "YOUNGSTOWN" CONTOUR ROLL LATHES

(Capacities 24"-36"-48"-60"-72")

The above sketch, made during construction, shows the typical design of "YF&M" contour roll lathes.

Automatically controlled, hydraulic or electric tracers which are "templet or numerically controlled" assure smooth operation, fine finish, and extremely close tolerances. Tool post and carriage are designed for use of either carbide-tipped tools or regular roll turning tools. Headstock has illuminated inspection ports . . . automatic lubrication . . . Timken roller bearings . . . herringbone gearing . . . Rugged throughout for extreme rigidity . . . No faceplate overhang. Higher headstock speeds can be furnished to accommodate ceramic tooling.

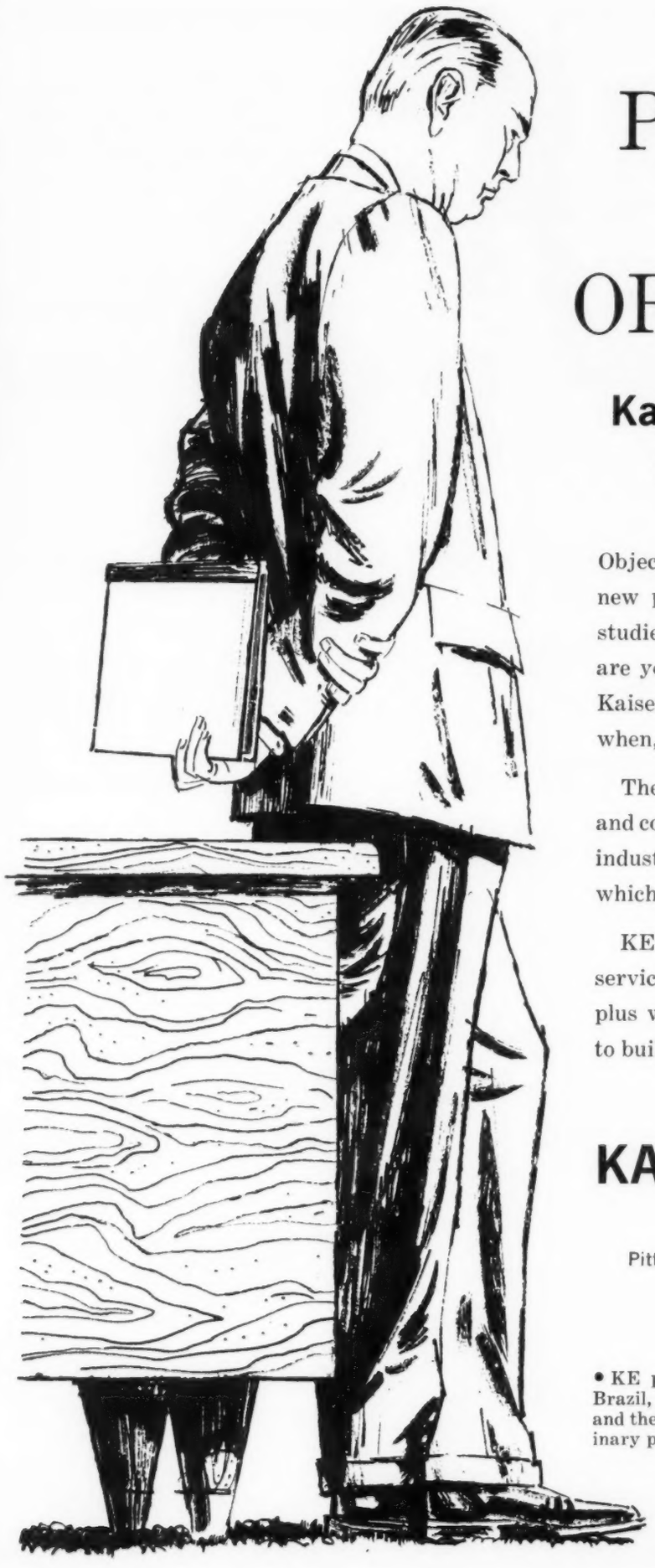
Heavy Duty spring-loaded tailstock with load indicator—avoids overloading of bearings. Housings—manually or hydraulically operated. Electric-Hydraulic Ragging attachment optional. Everything to meet specific requirements.

Write for complete information.

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown 1, Ohio



PROCEED, DEFER OR MODIFY?

Kaiser Engineers can help you decide

Objective analysis is vital to sound decision on new plant or expansion projects. Feasibility studies, economic analyses and site evaluations are yours by an outside, impartial firm when Kaiser Engineers is selected to help you decide when, how and where to proceed.

These services are in addition to the design and construction of major facilities for the Steel industry—including the proven L-D Process for which KE is the U. S. licensor.

KE offers complete, one-company, integrated service from concept through construction—plus world-wide experience and the ingenuity to build quickly, within budget.

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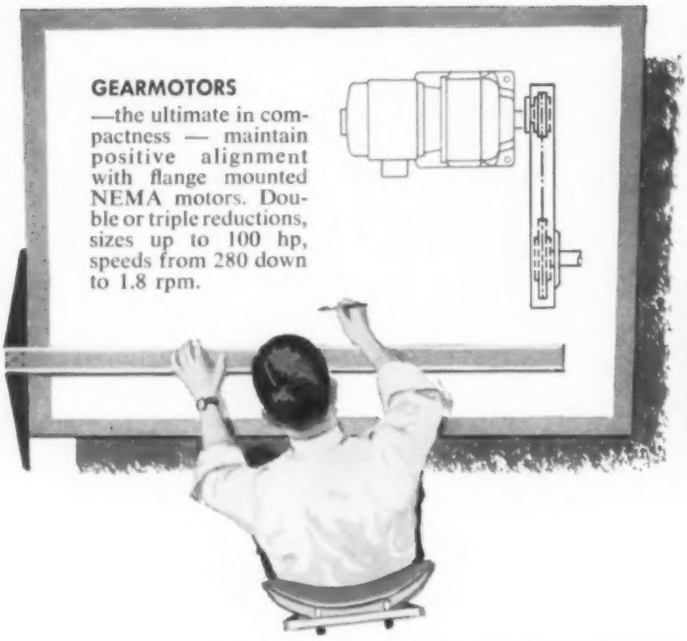
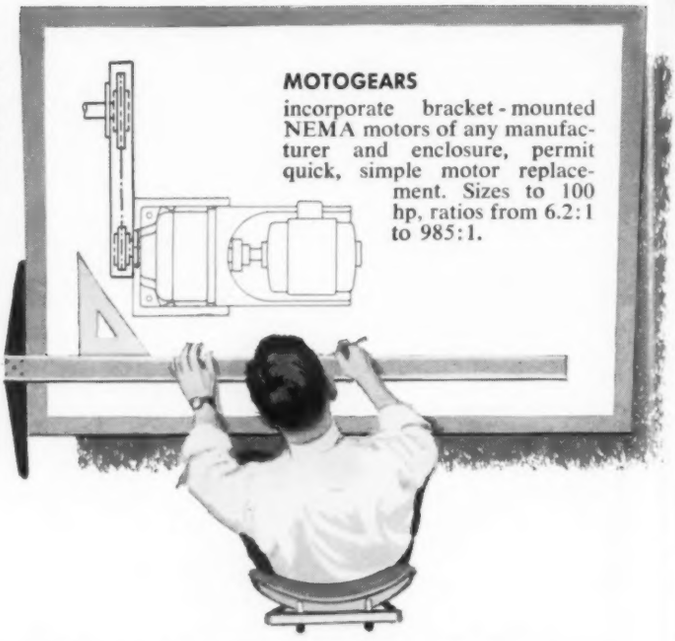
• KE projects include work in Argentina, Australia, Brazil, Formosa, Japan, New Zealand, as well as Canada and the United States. Assignments range from preliminary planning to plant construction.

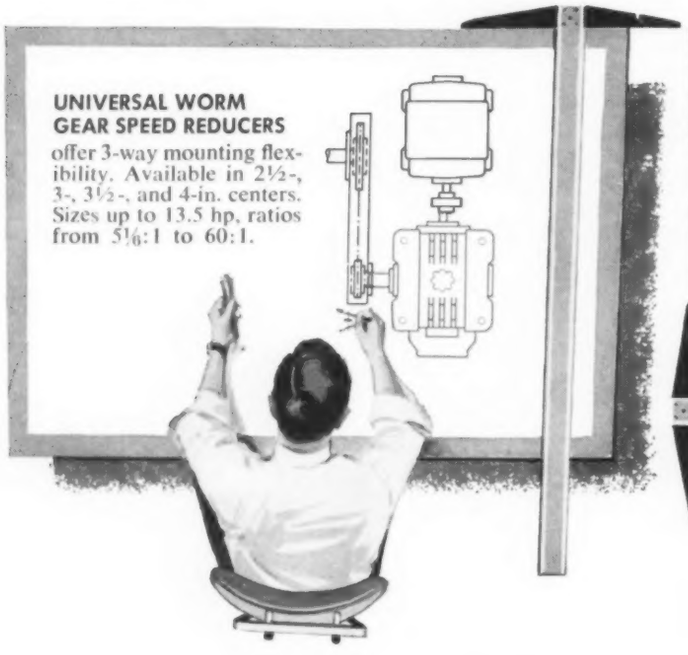
5458-S

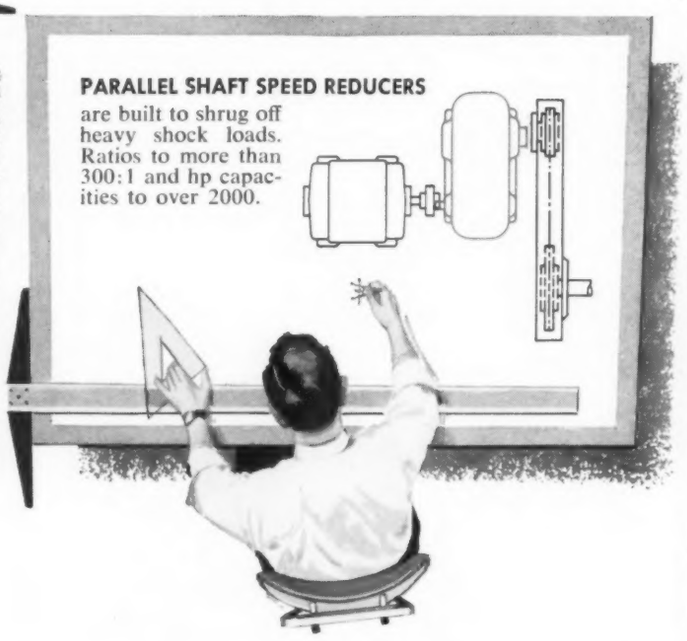

GEARMOTORS
—the ultimate in compactness — maintain positive alignment with flange mounted NEMA motors. Double or triple reductions, sizes up to 100 hp, speeds from 280 down to 1.8 rpm.

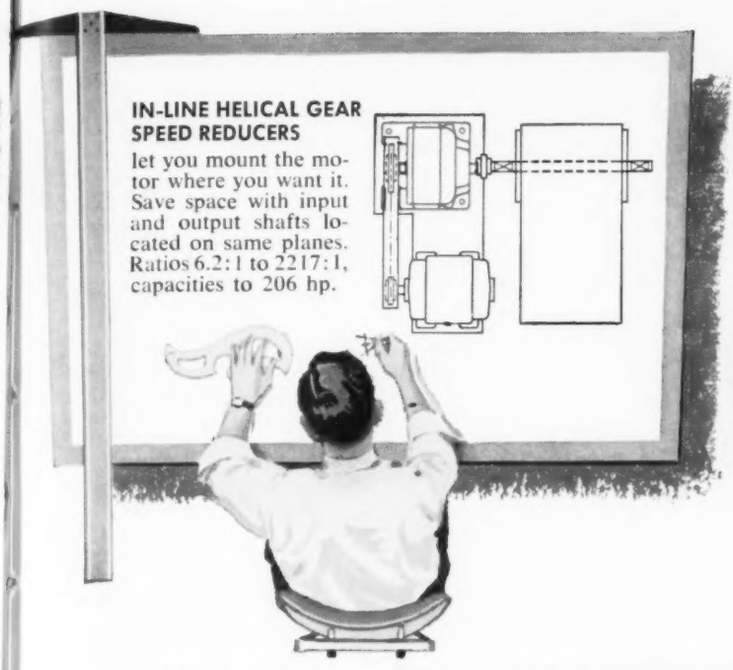

MOTOGEARS
incorporate bracket-mounted NEMA motors of any manufacturer and enclosure, permit quick, simple motor replacement. Sizes to 100 hp, ratios from 6.2:1 to 985:1.

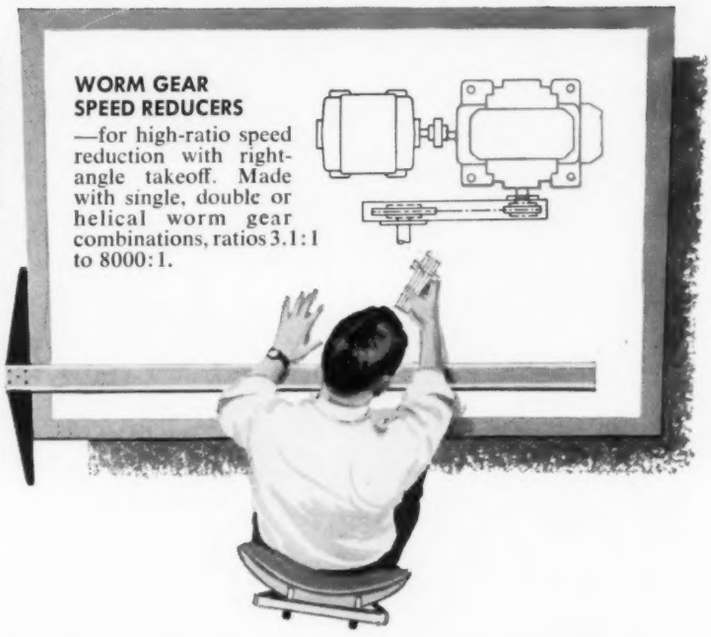
It's industry's only complete line—

don't limit


UNIVERSAL WORM GEAR SPEED REDUCERS
offer 3-way mounting flexibility. Available in 2½-, 3-, 3½-, and 4-in. centers. Sizes up to 13.5 hp, ratios from 5⅙:1 to 60:1.

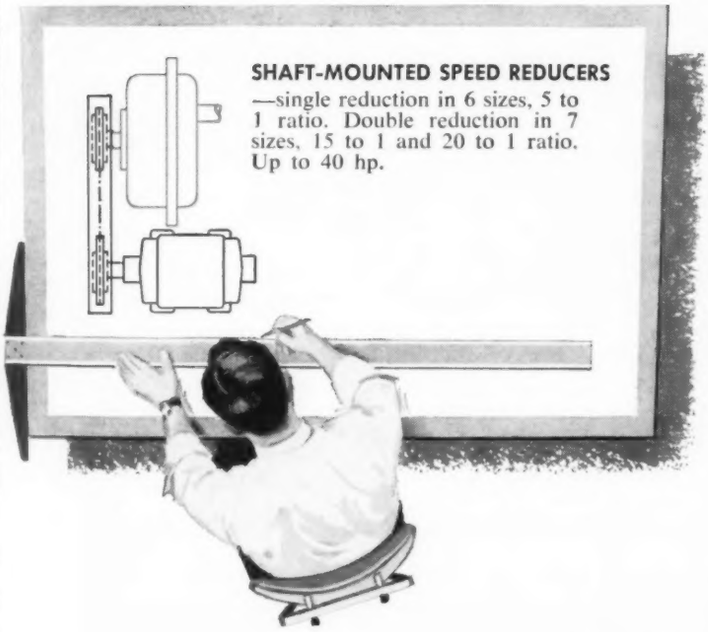

PARALLEL SHAFT SPEED REDUCERS
are built to shrug off heavy shock loads. Ratios to more than 300:1 and hp capacities to over 2000.


IN-LINE HELICAL GEAR
SPEED REDUCERS
let you mount the motor where you want it. Save space with input and output shafts located on same planes. Ratios 6.2:1 to 2217:1, capacities to 206 hp.


WORM GEAR
SPEED REDUCERS
—for high-ratio speed reduction with right-angle takeoff. Made with single, double or helical worm gear combinations, ratios 3.1:1 to 8000:1.

that's why LINK-BELT speed reducers

your layout


SHAFT-MOUNTED SPEED REDUCERS
—single reduction in 6 sizes, 5 to 1 ratio. Double reduction in 7 sizes, 15 to 1 and 20 to 1 ratio. Up to 40 hp.

Yes, you can plan with full freedom when you rely on LINK-BELT. *Seven* basic types of speed reducers—each in a wide range of sizes and ratios—give you complete flexibility in drive layout. It's easy to select the one that *exactly* meets your requirements for ratio, space, shaft position, shock loading and other specific factors.

And Link-Belt's leadership in speed reducers extends to every area of power transmission equipment. Link-Belt makes all related drive components—chain and sprockets, bearings, couplings—all dimensionally correlated with these reducers. This one-source responsibility eliminates need to exchange drawings with other suppliers and assures a matched set of equipment.

For full facts on Link-Belt's comprehensive line of speed reducers—including selection and features data—get in touch with your nearest Link-Belt office.

LINK-BELT

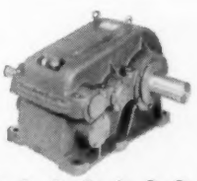
SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

UNIVERSAL WORM GEAR SPEED REDUCERS

SHAFT-MOUNTED SPEED REDUCERS

PARALLEL SHAFT SPEED REDUCERS



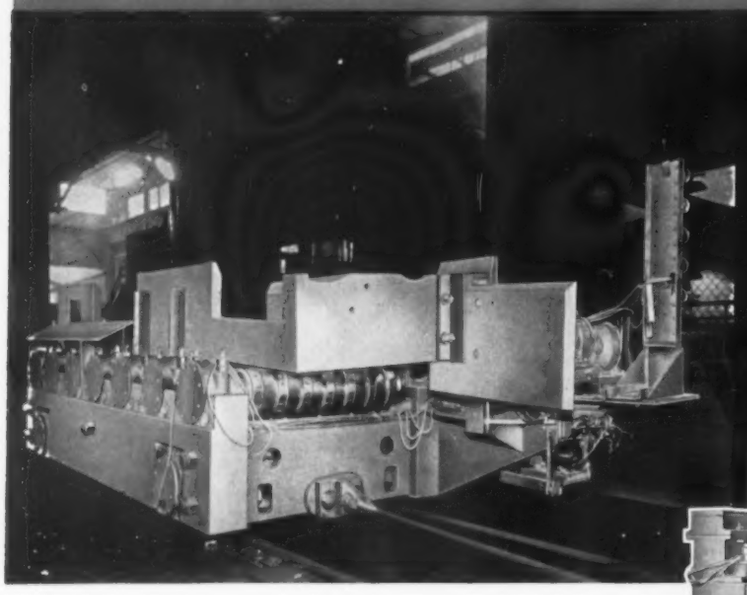
QUICK DELIVERY FROM STOCK.
Distributors, backed by 16 warehouses strategically located throughout the United States, assure immediate availability of all popular sizes of Link-Belt speed reducers.

15,148

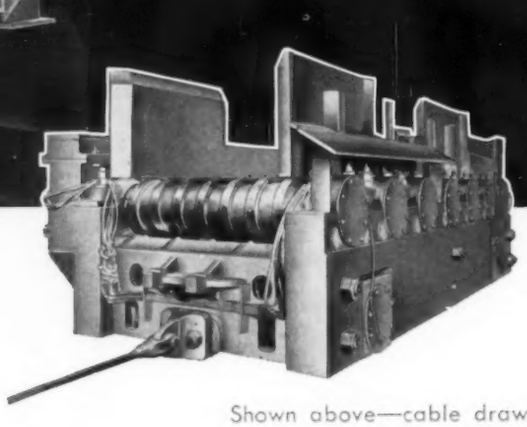
TREADWELL

cable-drawn **table-top INGOT CARS**

handling two 15-ton ingots... at a speed of 800 ft. *per minute*



Treadwell engineering was called on to develop the speed and efficiency needed for handling heavy ingots at high rates of speed. This ingot car has table rollers that are carried by anti-friction bearings and the axles are anti-friction bearing mounted. Write to Treadwell for any information on ingot cars.



- The table rollers are driven by Cleveland worm and gear sets and a Farval system for lubricating all bearings is built into the car.

Shown above—cable drawn table top ingot car at work in a major steel plant.

TREADWELL
ENGINEERING COMPANY • EASTON, PA.

SALES AND ENGINEERING OFFICES:

208 S. LA SALLE STREET
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CEntral 6-9784

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1015 FARMERS BANK BLDG.
PITTSBURGH 22, PA.
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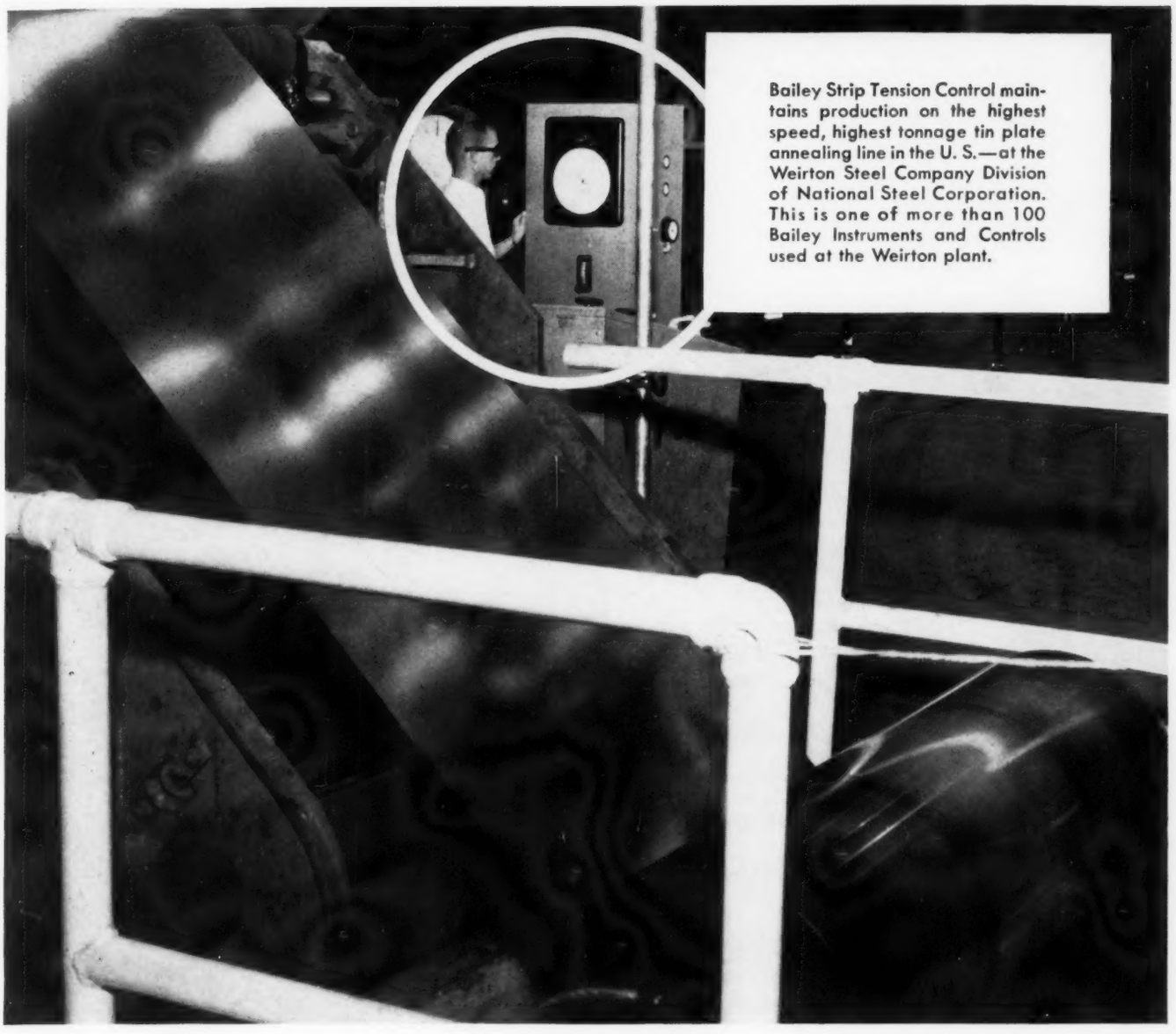
Gauges, Shear, Saw, etc.
Beds, Cooling.

Mills, Vertical Edging
Tables, Mill
Tables, Tilting & Lift
Tables, Transfer
Transfers

Beds, Inspection
Bumpers, Furnace
Pushers, Furnace
Repeaters
Handling Equipment (Kick-offs, Pilers, Cradles, etc.)

CASTINGS—Electric Furnace Steel, Ductile Iron, Gray Iron and Ni-Hard



Bailey Strip Tension Control maintains production on the highest speed, highest tonnage tin plate annealing line in the U. S.—at the Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls used at the Weirton plant.

Strip keeps rolling when Bailey keeps an eye on it

Installing Bailey Strip Tension Control will cost you far less than a single strip breakage in a furnace due to poor tension control . . . and it's the surest way of ending tension problems.

Strip tension at speeds up to 2000 feet per minute is pre-set, controlled, and recorded by this unique system. Bailey S.T.C. eliminates undue instantaneous strains through natural 'cushioning' of pneumatic control. It helps maintain strip flatness during finishing operation by minimizing slack formations, and it simplifies strip tracking by holding tension within allowable limits.

If you roll strip, see your Bailey Engineer about Strip Tension Control, or write the Iron and Steel Division for more information.

S114-1

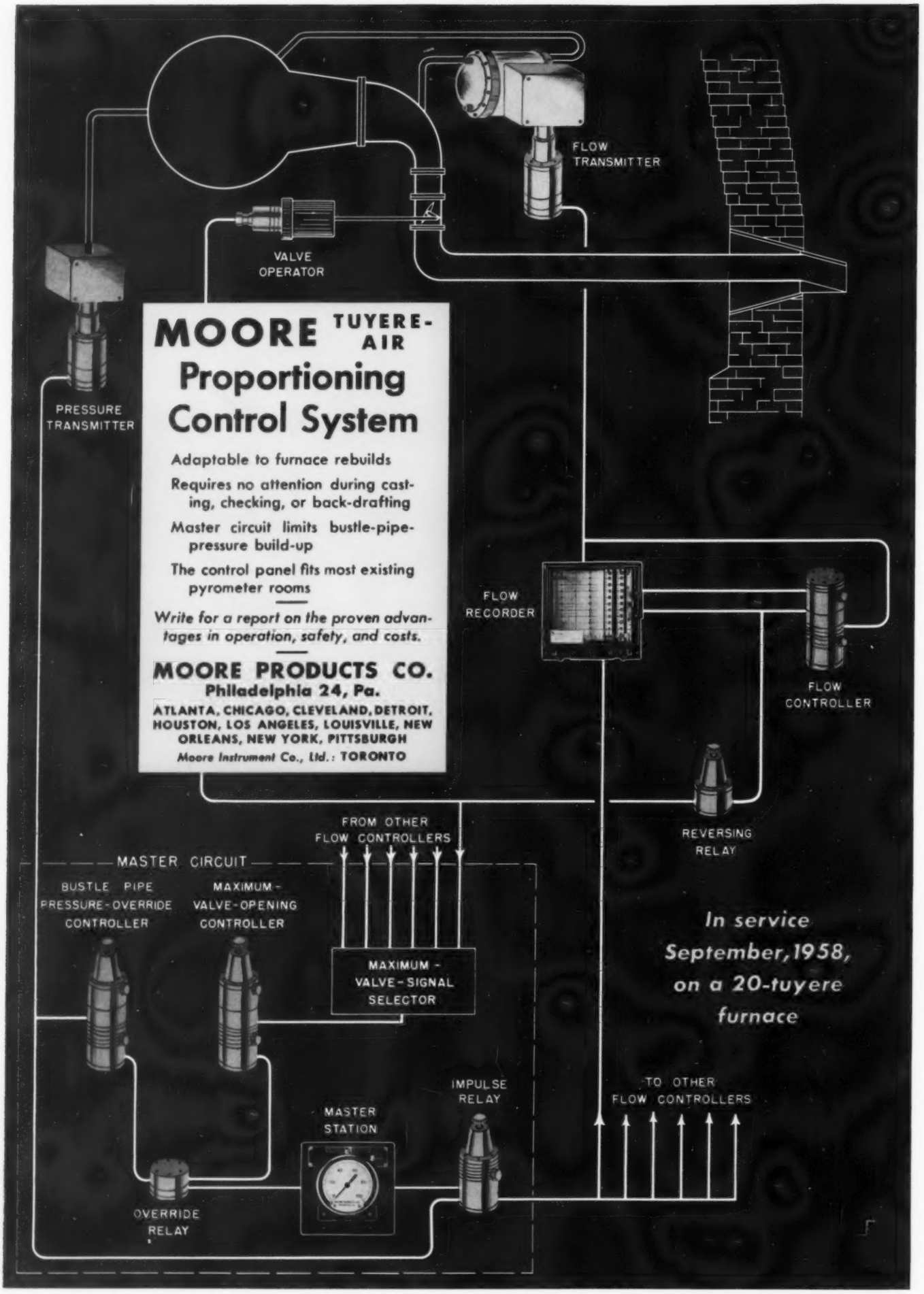
IRON AND STEEL DIVISION

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS


FLOW TRANSMITTER
VALVE OPERATOR
PRESSURE TRANSMITTER
MOORE TUYERE-AIR
Proportioning Control System
Adaptable to furnace rebuilds
Requires no attention during casting, checking, or back-drafting
Master circuit limits bustle-pipe-pressure build-up
The control panel fits most existing pyrometer rooms
Write for a report on the proven advantages in operation, safety, and costs.
MOORE PRODUCTS CO.
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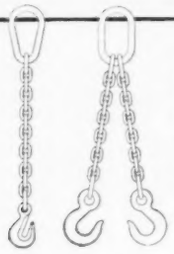
ATLANTA, CHICAGO, CLEVELAND, DETROIT, HOUSTON, LOS ANGELES, LOUISVILLE, NEW ORLEANS, NEW YORK, PITTSBURGH
Moore Instrument Co., Ltd.: TORONTO
FLOW RECORDER
FLOW CONTROLLER
REVERSING RELAY
FROM OTHER FLOW CONTROLLERS
MASTER CIRCUIT
BUSTLE PIPE PRESSURE-OVERRIDE CONTROLLER
MAXIMUM-VALVE-OPENING CONTROLLER
MAXIMUM-VALVE-SIGNAL SELECTOR
In service September, 1958, on a 20-tuyere furnace
IMPULSE RELAY
TO OTHER FLOW CONTROLLERS
MASTER STATION
OVERRIDE RELAY

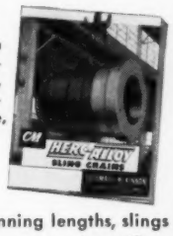
HERC-ALLOY

The Original Alloy Chain



● Has many superior features—is lighter, therefore easier to handle...is long wearing...has high resistance to impact loading...is Inswell welded. Chain and all fittings are 125,000 p.s.i. tensile strength alloy steel.

● Write for Bulletin 100 covering Herc-Alloy Sling Chains, including helpful information on their care, use and inspection.



● Sold in running lengths, slings assembled to customers' specifications and other special assemblies.

CM CHAIN

COLUMBUS McKINNON CHAIN CORP.

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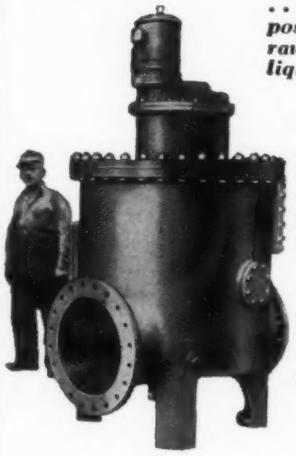
HERC-ALLOY®

More clean water at a lower cost with...

S.P. KINNEY AUTOMATIC SELF-CLEANING

STRAINERS

. . . for efficient removal and disposal of suspended particles from raw or process water and other liquids



- ✓ Over 1000 installations
- ✓ 2" to 48" pipeline sizes
- ✓ Installation on pressure or suction side of pump
- ✓ Over 8 billion gallons per day installed capacity
- ✓ Large variety of straining media

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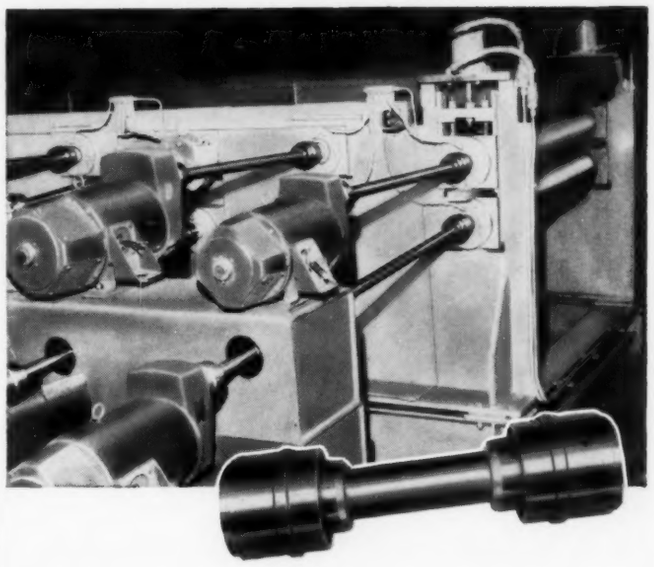
Write today for Bulletin 501.11 and list of installations

S.P. KINNEY ENGINEERS, Inc.

CARNEGIE, PENNSYLVANIA



Waldron Ships 67 New Series X Couplings to Major Fabricator for Use on Steel Line

GETS TREMENDOUS INTEREST FROM OTHER STEEL PLANTS

The rugged, new Series X coupling, recently developed by John Waldron for power transmission drives greater than the normal capacity of flexible gear couplings, is gaining wide acceptance by steel companies for use on annealing lines, trimming lines and similar equipment. The Series X can take up to 5° misalignment while transmitting maximum power.

According to H. A. Anderson, sales manager of the John Waldron Power Transmission Division, the new couplings have "created great interest in the steel industry because of their unique design and sturdy construction."

UNIQUE DESIGN

The success of the new coupling is largely dependent on its unique design. The Series X dismantles and assembles quickly. Removing two set screws disengages the sleeves from the hub allowing easy maintenance while keeping downtime to a minimum.

Specially designed seals keep the lubrication in, dirt and moisture out, even at the 5° misalignment capacity. An extremely close fit on the machined surfaces of the Series X rigid hub makes the coupling really solid. The design places the weight of the coupling on the rigid hub surfaces permitting the gear teeth to be used for driving only.

RUGGED CONSTRUCTION

High quality forgings are used for strength in the hubs and sleeves, while shafts cut to customer specifications are made of steel. Nylon plugs in the hubs prevent wear on the roll shaft ends. All parts are machined to extremely close tolerances.

SIZES AND RPM

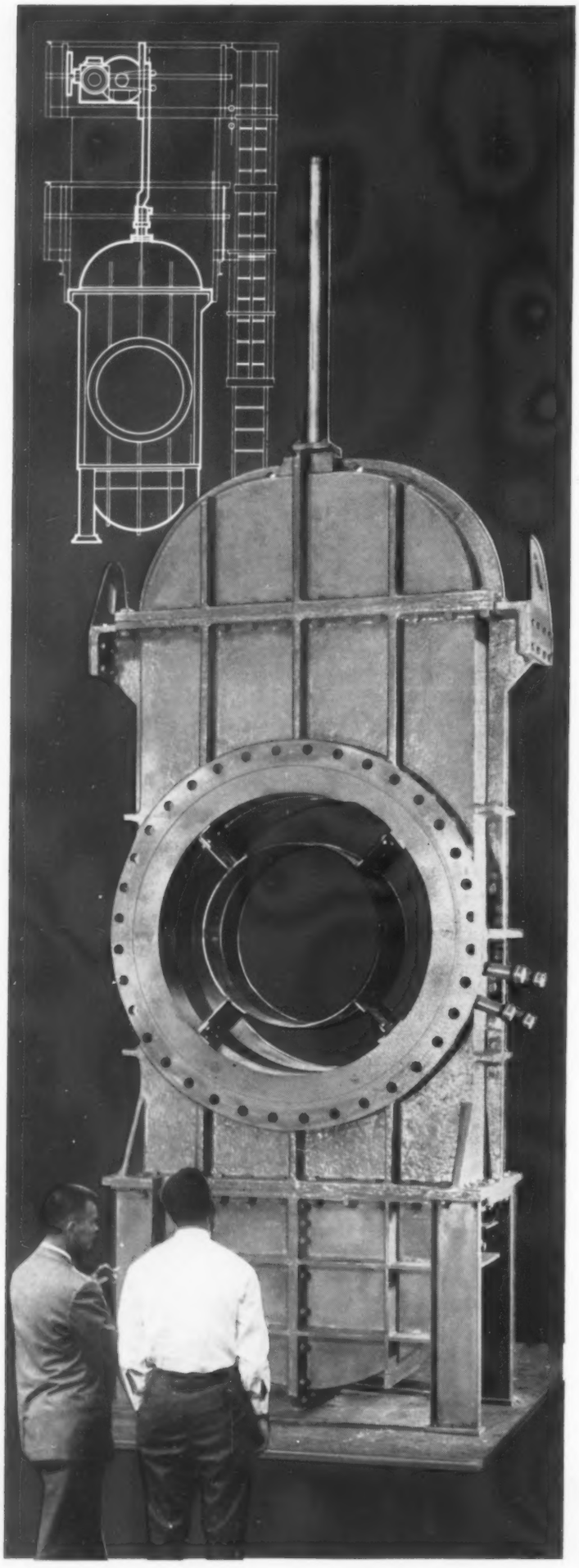
The new Series X coupling is available in bore sizes from 1¼" to 4½"; they will take from 3½ hp. to 210 hp. per 100 rpm. The couplings transmit smooth, trouble-free power from the driver to the driven units, even under high misalignment conditions.

M-R

JOHN **WALDRON** CORPORATION

Subsidiary of Midland-Ross Corporation

NEW BRUNSWICK, NEW JERSEY



NEW

fastest way of changing blast furnace stoves

BAILEY

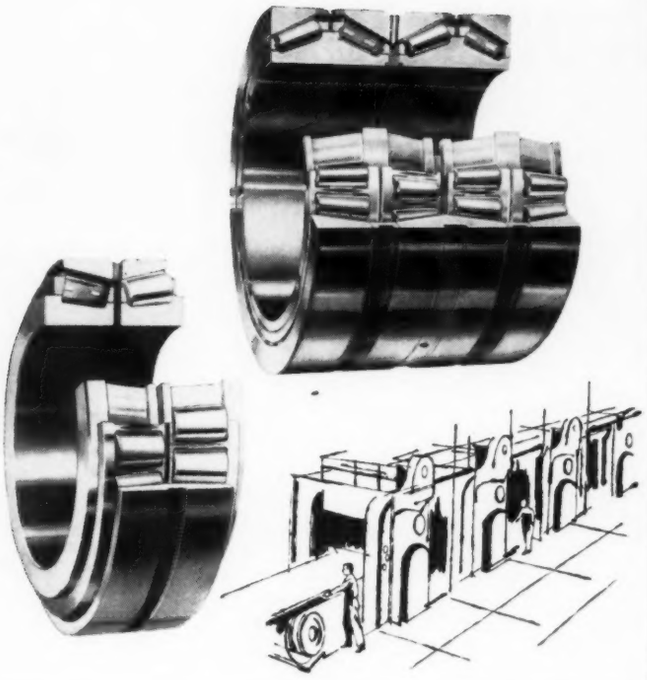
WATER-COOLED GAS BURNER SHUT OFF VALVE

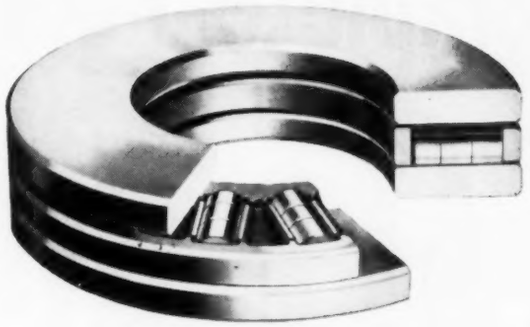
Full Open to Full Closed in 11 Seconds

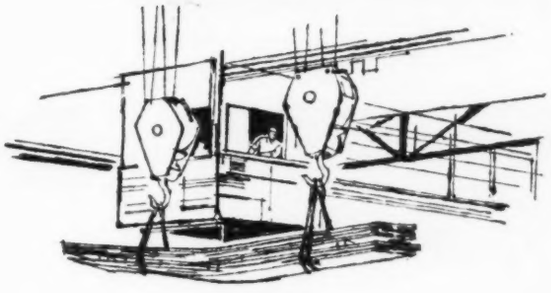
Valve disc and body are water cooled to prevent overheating while the stove is on blast. Motor-operated drive unit is located on a platform above the valve, well clear of stove heat. This valve is bolted tight to the burner and stove saddle flange, thus preventing leaks at the burner. *Write for Bulletin GB-100.*

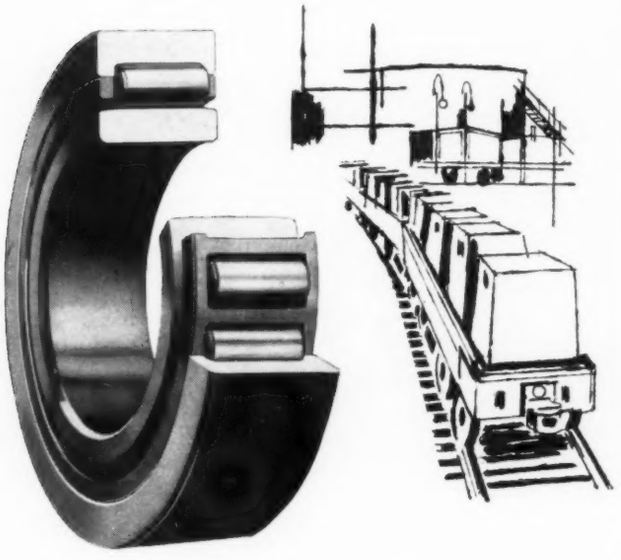
WILLIAM M. BAILEY COMPANY

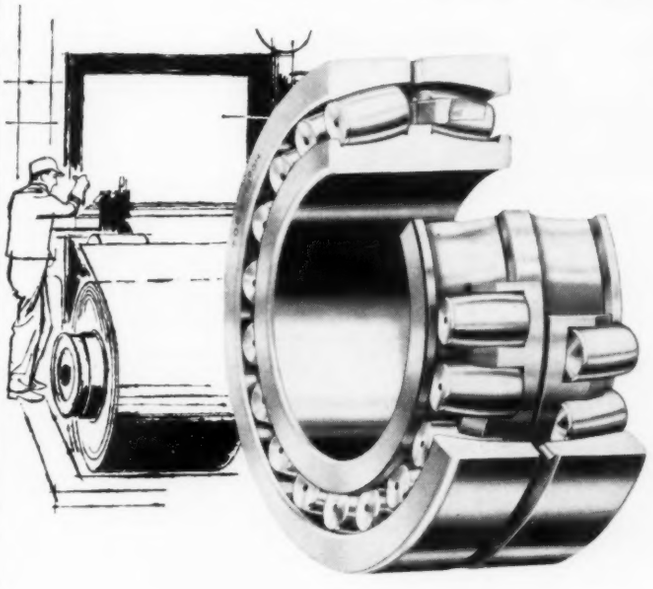
1221 BANKSVILLE ROAD, PITTSBURGH 16, PA.











TORRINGTON BEARINGS FILL THE BILL ALL THROUGH THE MILL

Torrington offers every basic anti-friction bearing to meet specific requirements of steel mill applications . . .

TORRINGTON ROLL NECK BEARINGS, two-row and four-row, solid and pin-guided tapered roller, for every type of service in work roll, back-up roll and back-up thrust applications.

TORRINGTON ROLLER THRUST BEARINGS for mill screw downs and crane hook service.

TORRINGTON CYLINDRICAL ROLLER BEARINGS for ingot car service.

TORRINGTON SPHERICAL ROLLER BEARINGS for mill drives, runout tables, coilers, shears and other auxiliary equipment.

In every detail of design, construction and metallurgy, you'll find each Torrington Bearing unmatched for performance and service life. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

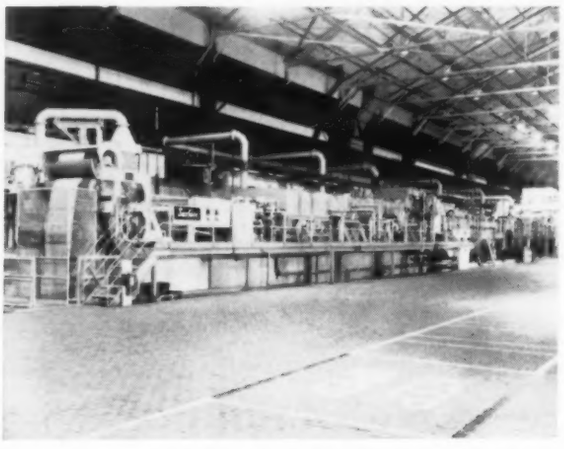
District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

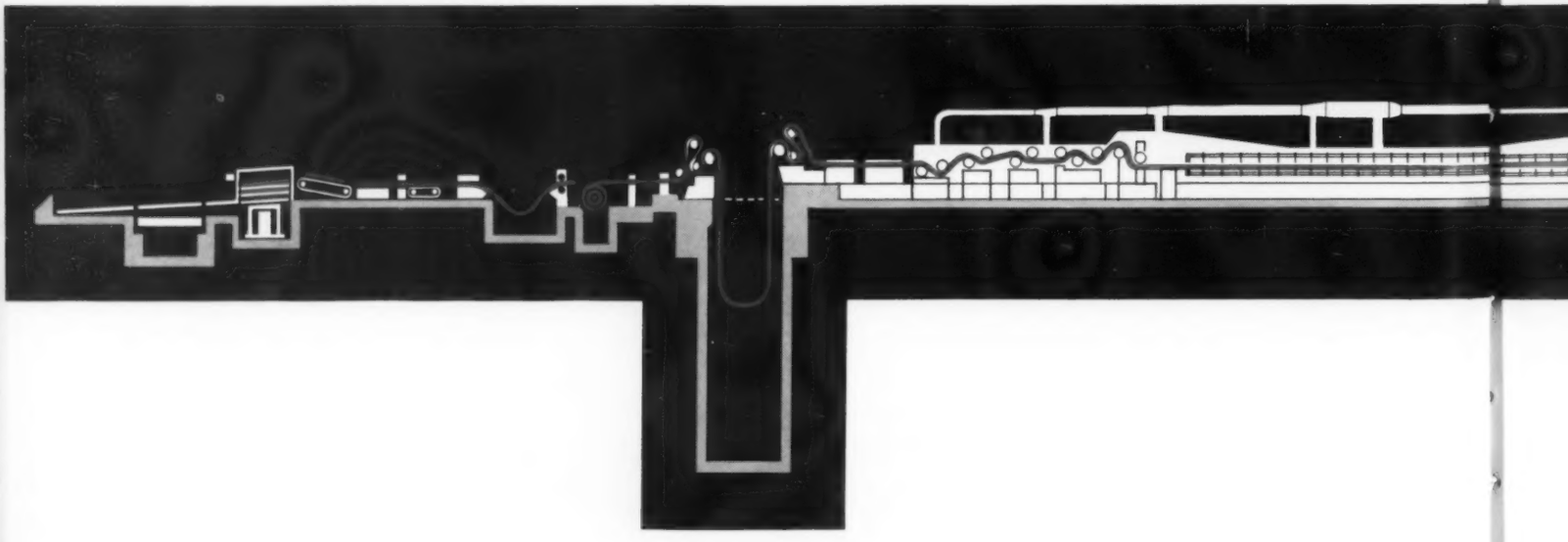
complete normalizing line:

ALL SURFACE!

Exit end of the line, showing looping pit, "re-coiler," automatic shear and sheared sheet piler.

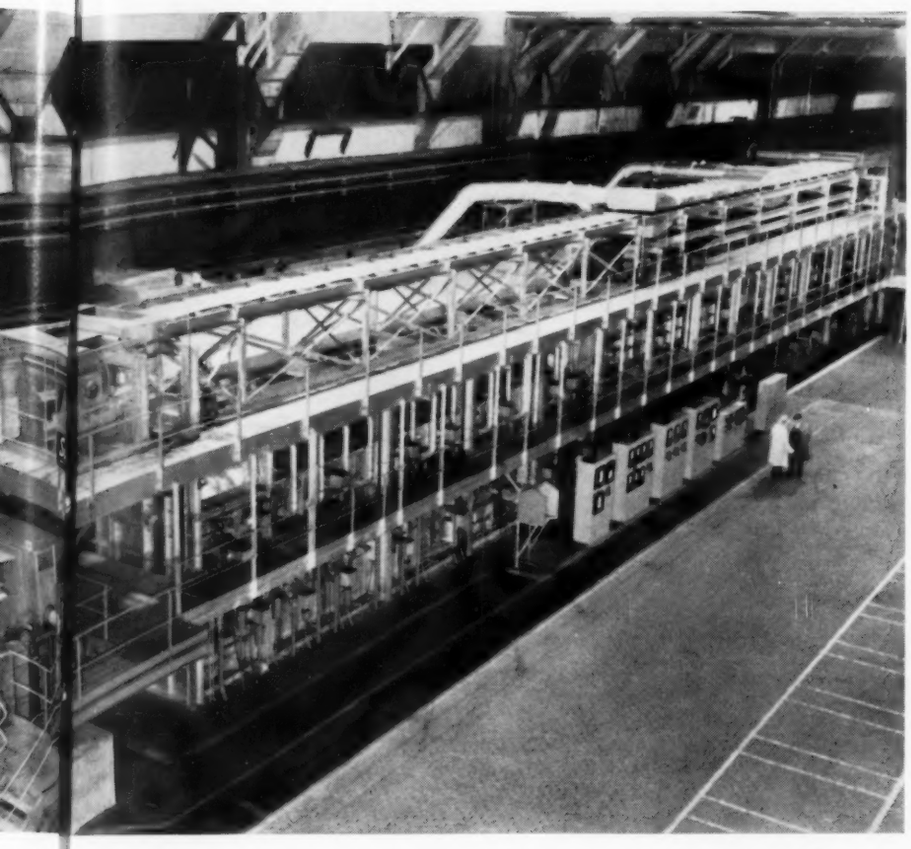


Pickling section includes acid bath, water rinse tank, brush scrubbers, alkali tank and dryer, all installed by Surface. This view shows the exit end of the section.

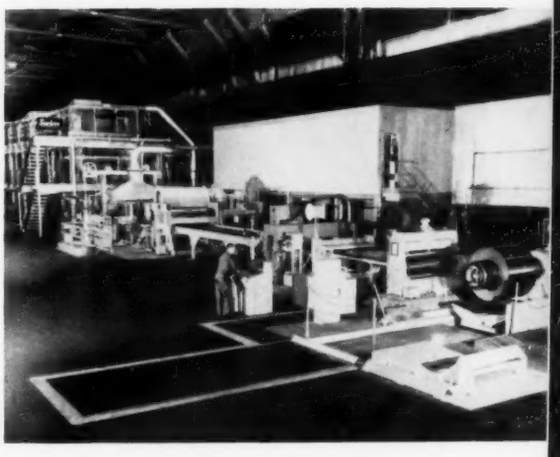


from payoff...to payoff

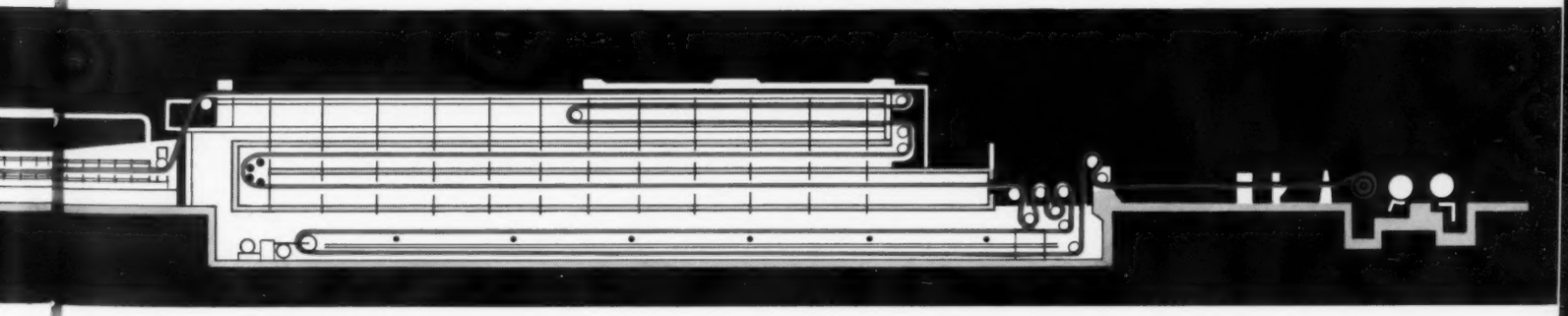
Worldwide engineering and manufacturing facilities through associates in
Australia • Belgium • France • Germany • Great Britain • Italy • Japan



Rockwells in the low 40's are achieved consistently in this three-level normalizing furnace. Heating zone is on the lower furnace level; convection cooling in the middle; air blast cooling at the top. A horizontal "looper" is located underneath the furnace.



Payoff reel marks the entry of low carbon stock after cold rolling. Speeds of 150 fpm on 60" wide strip are attained.



This complete new Surface normalizing line for vitreous enamel stock started paying off on its first day of operation. For example, its capacity of 30,000 lbs. an hour puts this mill forcefully into the market for deep draw quality strip. More than adding new selling power, this big line increased productivity per operator by an almost unbelievable amount.

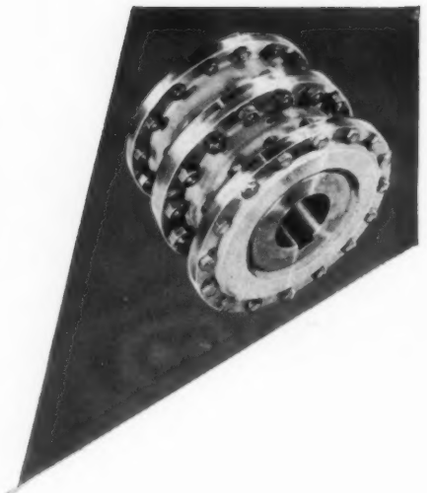
From payoff reel to real payoff, the entire installation is a graphic demonstration of Surface's qualifications as prime contractor. Applying its global experience in metallurgy, combustion, chemistry, and mechanization, Surface engineered and installed the complete line.

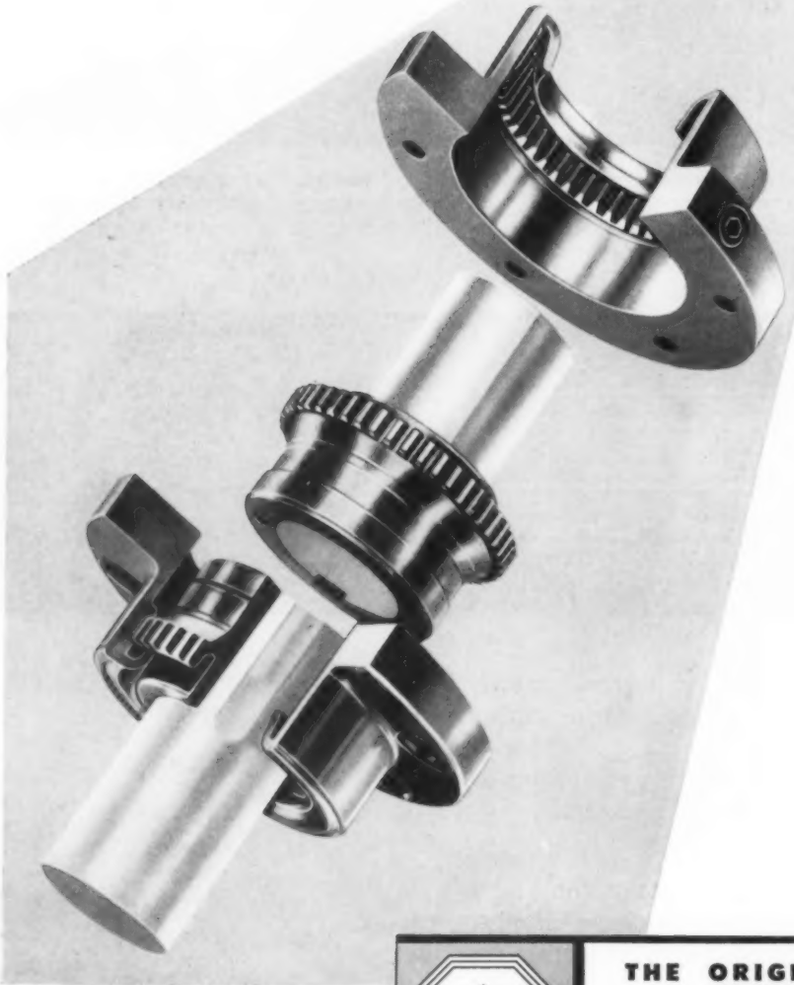
Take the opportunity now to evaluate the prime contracting skills available at Surface, and mobilize them for your profit, ***wherever heat is used in industry.***

Surface

SURFACE COMBUSTION CORPORATION *2404 Dorr Street, Toledo 1, Ohio*

the basic coupling principle that couldn't be improved . . .





This principle makes every Fast's coupling . . . large or small . . . out-perform all others

The principle embodied in Koppers gear-type, self-aligning Fast's couplings couldn't be improved by anyone. Throughout industry, Fast's couplings are accepted as the most dependable couplings on the market. Experience has proved that they frequently *outlast the equipment* they connect.

Fast's couplings are sufficiently comprehensive in types, sizes and versatility to meet almost every known need for couplings. Available in forged steel for shaft sizes from ¾″ to 6⅜″ and in cast steel for shaft sizes from 5½″ to 32″.

Nearly 40 years of coupling experience guarantees that Koppers can supply the right coupling engineered for a given application. For the booklet describing Fast's couplings applicable to your equipment, write today to: KOPPERS COMPANY, INC., Fast's Coupling Department, 5009 Scott Street, Baltimore 3, Maryland.

KOPPERS

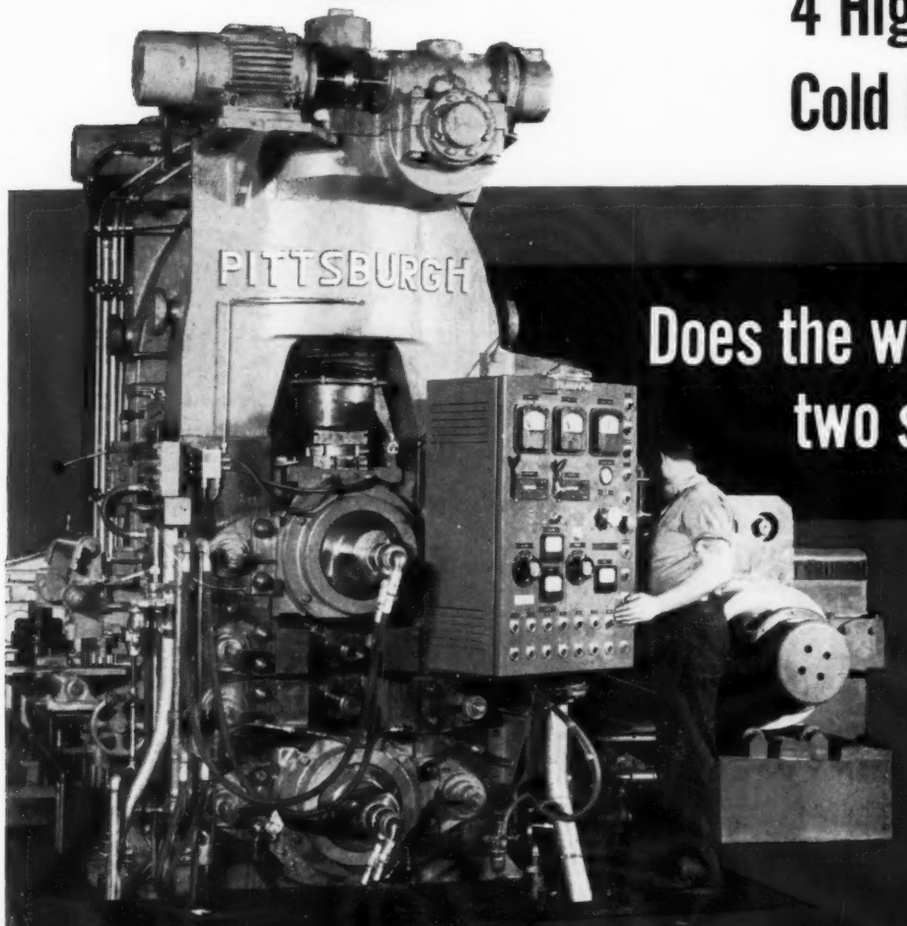
THE ORIGINAL

FAST'S Couplings

Engineered Products Sold with ***Service***

PITTSBURGH

Combination 4 High/2 High Cold Mill . . .



Does the work of two separate mills

"Precision" and "Versatility" are the words that best describe the new combination 2 High/4 High Cold Mill designed and built by PITTSBURGH to secure precision gauge, temper and finish for the ferrous and non-ferrous industries. As a 4 High Mill, it is used for cold reducing; as a 2 High Mill, it is used to acquire the desired temper and finish. Several desirable design features are incorporated to keep roll change time to a minimum. Low initial cost and economical operation are attractive plus values.

"Electric and open hearth steel castings from 1 lb. to 100 tons"

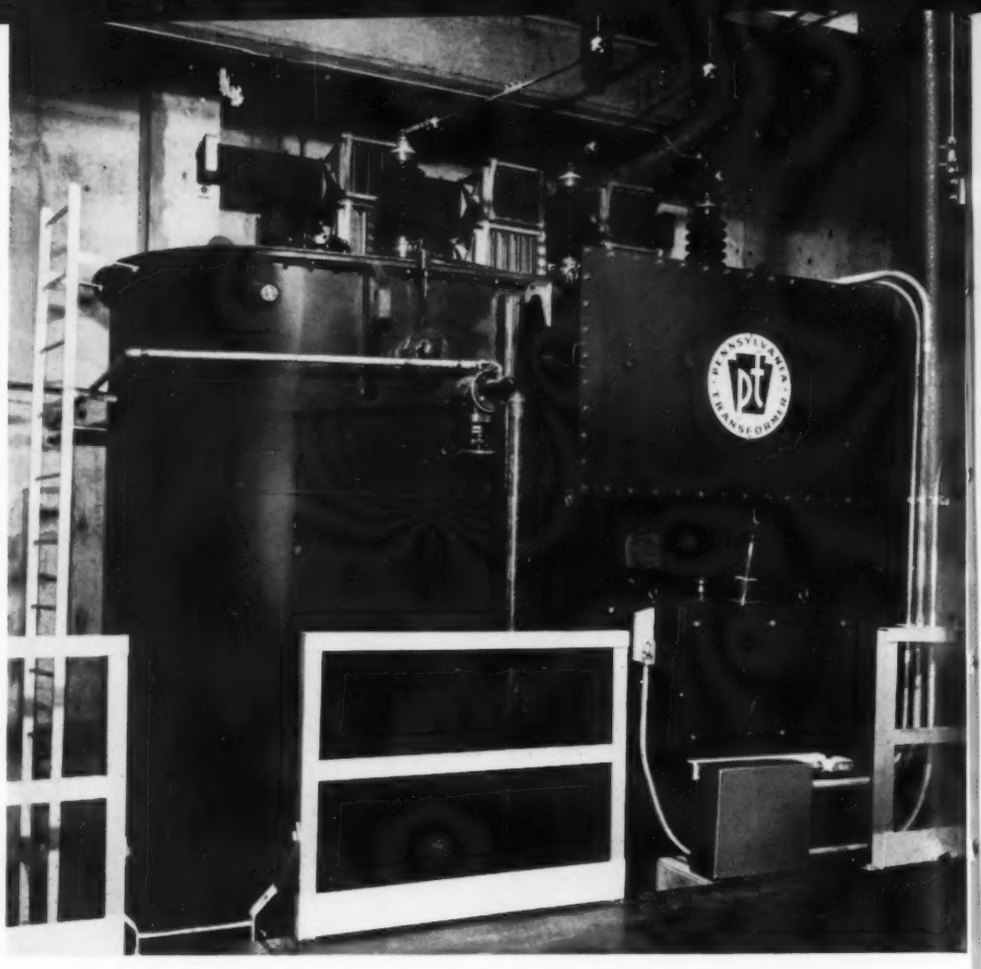
HEAVY MACHINING FACILITIES

Our plant is equipped with a superior complement of well diversified machine tools that are available on a continuing basis for economical machining of heavy castings or the manufacture of auxiliary rolling mill equipment, such as heavy mill tables, furnace pushers, slab depilers, downcoilers, ingot buggies, slab transfers, etc.

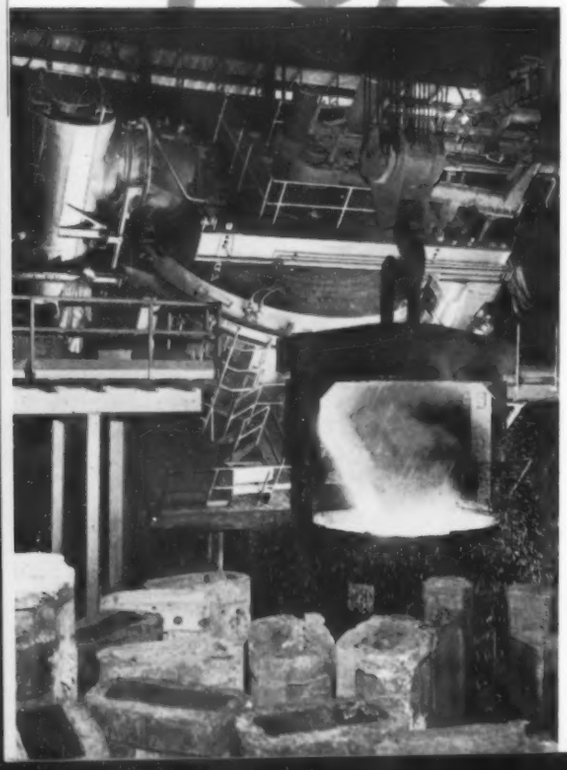
PITTSBURGH
ENGINEERING & MACHINE DIVISION
Pittsburgh Steel Foundry Company
TEXTRON, INC.

BOX R, GLASSPORT, PENNSYLVANIA · PLANTS AT GLASSPORT & McKEESPORT, PA.

Pennsylvania Furnace Transformers help BOOST INGOT CAPACITY 70%



One of two such units at a leading West Coast steel plant, this 25,000-kva Pennsylvania Furnace Transformer is helping set new production records at lower cost per ton. The transformers supply power to two 100-ton Lectromelt Furnaces—also products of McGraw-Edison Company.



Two 25,000 Kva Transformers Team up with Lectromelt Furnaces in Replacement of Open Hearths

Replacement of gas-fired and oil-fired open hearths by two 100-ton Lectromelt Furnaces has increased the annual capacity of a leading West Coast steel mill from 246,000 to an estimated 420,000 ingot tons per year . . . while costs per ton have been substantially lowered.

A dependable, efficient source of power is of prime importance in the establishment of such a record. Two 25,000-kva Pennsylvania Furnace Transformers are meeting the challenge—converting the 34,500 volts supplied by the utility to low voltages that range from 450 to 300 volts. The maximum line current is 37,100 amperes.

Pennsylvania Furnace Transformers can withstand the repeated short circuits and heavy overloads that are characteristic of such service because of design and construction features that have stood the test of decades. These include electrically balanced, precompressed coils . . . extra sturdy bracing of coils and bus bars . . . and a coil design in which individual conductors are transposed to reduce copper eddy losses.

To reduce down time during periodic inspections, the motor-driven tap changer is housed in separate compartments that are isolated from the main tank. The tap changer has a provision for emergency hand operation.

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PENNSYLVANIA TRANSFORMERS

by A. J. Mosso, Executive Vice President
Auburn & Associates, Inc., Pittsburgh, Pa.

COST ESTIMATING— METAL WORKING PLANTS

. . . . preliminary cost estimates made prior to the detailed engineering of plant expansions can be made sufficiently accurate for realistic appropriation requests . . . .

FROM the conception of a new ferrous or nonferrous plant to its ultimate completion, many cost estimates are made. Each serves its own specific purpose. There are "guestimates" used in preliminary discussions, estimates for appropriation purposes, estimates made for cost control, contractors' estimates used for quotation and, perhaps, other.

It is the intention of this paper to cover estimates generally required of the metal working engineer which can be used for appropriation requests or, if done with sufficient accuracy, could be used to control costs of the project at hand.

It is emphatically stated that it is not the intention of this paper to discuss the thorough and accurate methods used by contractors to prepare bids. This would require a paper in itself and would not serve the purpose intended herein. It must also be made clear that data which are a part of this paper do not represent actual cost of any given project in any given location. The data do, however, represent the average costs of steel plants over a large portion of the United States and projects having a value of $15,000,000,000 or more.

Approximately once every 20 or 30 years, a plant has a major expansion or replacement program. On these occasions, the vice president of the company generally calls the chief plant engineer to say that management's plans are to proceed with the purchase of a new blooming mill, hot strip mill, tube mill, or a large processing line. How much will it cost and can I have the answer "yesterday"? The engineer, whose chief duties had been maintenance engineering, suddenly finds himself in a whirlpool with millions of dollars going by him in every direction. He will call friends in the industry who have built similar mills and finds that costs may vary 100 per cent for supposedly identical mills. His contractor friends will give him guesses that vary by 100 per cent or more.

Since the mill engineer is most familiar with what is required in a new program, it is only logical that he make the early cost estimate. One logical and successful approach to this problem is outlined in this paper.

To determine project costs, early in the program, it is imperative that the estimator, assuming that he is a steel mill engineer or an engineer in an outside firm, have a good knowledge of certain basic facts which will influence the estimate considerably.

The most important fundamental knowledge required is as follows:

1. He must know the history of the customer or his own company, as the case may be.
2. He must know the location of the project.
3. He must know when the equipment is to be bought and when the construction program will be executed.
4. He must know what the customer or his own company wants.

The history of the plant or company is very important in making early estimates for construction costs. Some people insist on going in a Cadillac, while others feel that you can arrive at the desired end just as fast in a Ford. Construction costs vary accordingly.

The location of the project will influence costs considerably. Freight and labor costs vary with areas. Site preparation and soil conditions will influence foundation costs by 25 to 40 per cent. Proximity to

existing facilities and the necessity of adding new facilities in crowded sites will add considerably to overall costs of both engineering and construction.

The economic conditions at the time of equipment purchases, in the competitive American market, has made on many occasions a surprising difference in costs. Likewise, construction costs will often change during the progress of a large expansion program. Both the quality and cost of labor will vary not only as to areas but as to time.

No one can even approximate costs unless the plant wants are known. Basic mill specifications, its productive output, speed, size and associated auxiliaries should be known with some degree of accuracy. Two unknowns which cause the most trouble are as follows:

1. The flexibility to be built into the mill. If, for example, a cold mill is to be built having a speed of 7500 fpm which cannot be operated at more than 5000 fpm, the cost will be higher. However, a company may be willing to spend this additional money to incorporate this potential speed and resultant flexibility to preclude the possibility of mill obsolescence by some new discovery.
2. The omissions in an estimate are always fatal to the estimator. It must be emphasized that the power and fuel departments, security department, safety department and operating departments have reviewed the program so that their needs are known. The best estimate will be worthless if any of these departments come along later to say, "if you need that much steam, we will have to install a new boiler; if you need that much power, we will have to install a new substation; if you need that much air, we will require a new air compressor, etc."

Many additional factors will influence the experienced estimator, such as the ability of the individuals responsible for directing the job, the project size, and who will do the construction and fabrication.

SOURCES OF INFORMATION

With this knowledge, an estimator has a good beginning but a major expansion program has so many and such varied fields to cover that no one individual could possibly handle all of its ramifications. The estimator will need help. Where does he get it?

In estimating the cost of a metal working plant, perhaps the best friend could be the mill builder, the machinery companies can provide accurate estimates of the mill equipment costs, a drawing of the mill general arrangement, the approximate weights of the mill components and an electrical motor list.

The next best friend will be the electrical manufacturer who could, in turn, provide the cost of electrical drives and associated control equipment.

The cost of the mill with the necessary electrical equipment will represent a major share of the total expenditure. It is, therefore, necessary that major equipment prices be established with considerable accuracy. It is suggested that inquiries issued by the purchasing department for quotations, acceptable for the placement of orders, be obtained.

The engineering organizations, who have made construction drawings for many mills, can often provide valuable data on quantities required for installations.

The contractors can often provide up-to-date unit prices and variations caused by location and job size.

The miscellaneous suppliers such as crane builders, roofing and siding fabricators, etc., can provide valuable information, too.

The plant operating, maintenance and safety divisions should be consulted early in an expansion program. These groups can often point out problems with previous installations that should be solved on new installations. A compromise between the wants of these groups and the willingness of management to approve the appropriation may have to be made.

Not to be overlooked as a source of information are the economic forecasts. Labor and material escalation will determine to a considerable extent the closeness of estimate to actual costs. Trade journals and government publications carry this information in detail. In addition to forecasts which predict price increases while the job is in progress, trade and government publications indicate the amount of construction activity in the area of a new project. This information can give an insight to the quality and quantity of labor available and determines whether or not an extended work week will be necessary. A 6-day work week will increase labor costs by 10 per cent.

Labor unions are a good source of labor rates in any area. If a request is diplomatically made, they will often provide anticipated increases which may occur during the course of construction.

In addition to these sources of aid, the mill engineer must have the services of at least one experienced civil, one electrical and one mechanical or piping engineer. To make an estimate of any accuracy will require at least 30 days of concentrated effort.

PREPARATION

Now that one has the basic acquaintance (in most cases one's own company), the sources of information and the necessary help, one can prepare to make the cost estimate.

Like any other job, if one intends to make a cost estimate which will have any real value, some preparation must be made. How much preparation depends on the accuracy desired. Since equipment prices can be obtained from vendors, the obvious problem and the largest pitfalls occur in establishing the construction costs. On the last ten major projects with which this author has been acquainted, formal quotations obtained from qualified contractors, while engineering was still in a preliminary stage, showed wide variations in prices. Estimating is not an easy task when it is done before engineering is well under way. Hours of effort expended in preparation is time well spent indeed. This statement cannot be overemphasized.

Tabulated below is a list of minimum preparation, if an estimate of costs is to be made sufficiently accurate to be used as a part of a cost control scheme.

1. A general arrangement of the mill machinery with the approximate weight of its components and crane clearance dimensions must be obtained.
2. A motor list and, if possible, the sizes of the main motors, motor-generator sets or rectifiers should be obtained or sized by an experienced engineer. The air cooling system must be roughly planned.

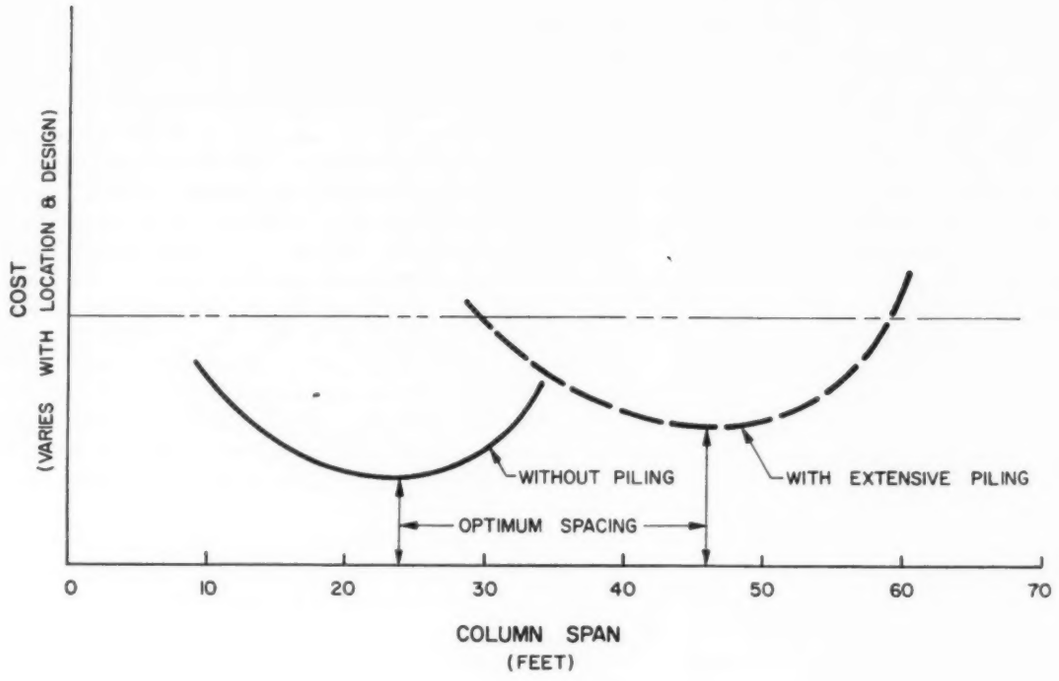

Figure 1 — Building steel and foundations column spacing vs cost with and without piling.

These two items are generally received from or worked up in conjunction with the mill builder and electrical manufacturers. From this information, other preparations can be made.

The first of these engineering preparations should be a map of the area or job site showing truck roads, railroads, pump houses, sub-stations, fire house and any other auxiliary equipment required to make the mill function.

The second of these items should be a motor room layout. This should be done to at least a ¼-in. scale to enable one to determine the size, including depth of basement of the motor room and the ventilation room. Equipment should be represented as blocks to indicate both the approximate size and the location of motors, rectifiers, motor-generator sets, control and switchgear equipment.

A very important drawing is next made. This is the crane and mill equipment clearance drawing which is essentially a drawing to determine the length, width and height of the mill building and building column spacing. Supplementing this drawing should be a typical roof truss and column (both crane and building) drawing showing actual design sizes for structural steel.

Soil conditions and site preparation studies should be made. Often soil conditions are available from previous projects or from a neighbor who has built plants in the area.

An approximate incomplete conduit and cable schedule should be written from the motor lists.

Overhead lighting and outside lighting can be superimposed on the plant map. This need only cover the number of fixtures.

A single line diagram of sewers, drains, steam, gas, air, water and electrical services should be superimposed on the plant map.

Piping installations for mill oil cellar and interconnecting piping for hydraulic, lube, spray and other systems can most readily be obtained by using drawings made for similar mills. This is also generally true in determining the oil cellar size.

On some extremely complicated jobs or unusually large jobs, scale models could be desirable. A model helps the operating and management personnel, who are not always familiar with engineering drawings, to visualize the complete project. Basic planning errors are sometimes prevented and it is much easier to sell an appropriation request to management if a model is available. Model costs are high and are not always easy to justify.

The above is a bare minimum of effort, if one plans to come within five per cent of actual cost.

Some segments of the steel industry, despairing over the repeated failure of plant engineers to estimate with any accuracy, are now having preliminary bid drawings made with sufficient information to permit firm lump sum prices to be obtained from contracting firms. The cost of these drawings is approximately 25 per cent of the total cost of the construction drawings. However, 10 to 15 per cent of these drawings can later be used as installation drawings. This author, believing that an estimate can be made to an accuracy of two per cent, questions the necessity of this procedure.

PROCEDURE

To best illustrate the procedure of making a cost estimate, assume a simplified and fictitious project consisting of only one mill housed in one building. To make the story complete, assume that this mill has the supporting outside equipment such as fire protection, sub-stations, etc. Table I indicates the items to be considered and the headings under which each is to be listed. The account numbers are required by accounting departments.

The quantities are, of course, fictitious; however, the unit prices are good average prices for the first quarter of 1958. One must caution at this point that many factors affect unit prices. The cost per foot of driving piles, for example, may vary by as much as 300 per cent depending on soil conditions. Many other items could be influenced by specific conditions on a project

which will cause unit costs to vary widely. A good sense of values, sound judgment, and experience are absolutely essential if a good job is to be done. Statistics in the hands of inexperienced people can be very dangerous. For one's last project, perhaps he paid more and perhaps less. The author can prove that every unit price listed in this table is off by a large percentage for any given job. Financial statistics can be quite controversial and often misleading. It cannot be overemphasized that any financial data must be used with discretion. The dare, however, has been accepted, so let us proceed to point out how quantities are established before engineering drawings are made and discuss the factors affecting unit prices.

With these words of caution, let us look at Account No. 1 on Table I which covers site preparation. This item covers a wide variety of conditions. It would be impossible to cover all probabilities but let us look at the cost of some of the most common requirements.

Slag, which is always prevalent near steel mills, is often used for fill and it can be delivered for $1.40 a cu yd if the site is in proximity to the supply. In the Great Lakes area sand, which can be pumped by sand suckers, is also used and it can be obtained for $1.30 per cu yd. The cost of bulldozing and rolling averages approximately $0.05 per cu yd.

If the site is one where existing facilities must be removed or rerouted, the underground services are merely abandoned and new sewers, duct runs, etc., installed. Cost, then, must include only the new underground facilities and data used for new installations can be used. Often concrete must be removed and the cost is sometimes high; it will vary between $50.00 and $100.00 per yard, depending on the difficulties involved.

New excavation for mills is seldom expensive since the necessity of locating mills near large sources of water generally brings soft soil which can be removed for $1.50 per cu yd. In areas where slag fill has been used, the cost of excavation will be four times the cost of soft soil removed. Backfill which is invariably required and often needs to be compacted, will cost approximately $4.00 per yard. Quantities required for estimating costs are easily obtained and need no discussion. The cost of site preparation is often very high as the estimate on Table I indicates.

Account No. 2 covers the mill building foundations and the quantities are neither easy nor difficult to obtain. If preparations listed above have been completed, the number and type of piles can be readily estimated.

Concrete-filled pipe piles 10 in. in diam will cost $5.00 to $5.50 a ft completely installed and cut to elevation. "H" piling, because of the material involved, will cost $8.50 per ft and, concrete caisson prices are listed in the tabulation. In those applications where caissons can be used, the over-all cost of piling is generally less than other types.

Sheet piling is often used to protect existing facilities or to facilitate concrete pours. The important thing to know is that costs vary from $1.00 a sq ft to $7.00 a sq ft for driving, depending on soil condition. There is also salvage value for piles that are pulled which should reduce the over-all cost.

Foundations for column piers require about 30 sq ft per cu yd of forming and grade walls approximately 50 sq ft per cu yd of forming. This increases the cost of concrete $25.00 to $30.00 per cu yd above the average cost of machinery foundations. Note that the price of $70.00 per cu yd includes excavation, backfill, forming and concrete poured and forms removed. A hundred pounds of reinforcing bar are required per cu yd of concrete and roughly 10 lb of anchor bolts per cu yd. The breakdown shown here is one often used to place foundation installation contracts on a unit price basis. The quantities used are in proportion to normal averages. It should be noted that concrete costs in the South run 10 per cent to 20 per cent less than in the North if other conditions are equal. Also to be remembered, if the job is small and only a 1000 or less cubic yards are required for the entire project, the cost per yard of concrete will be twice as high as indicated.

Account No. 3 covers the building above foundations, except the cranes. The largest cost item is the structural steel frame which can be obtained designed, detailed, fabricated and erected for $325.000 to $350.000 per ton. The quantity can be established by determining the tonnage required for one bay and multiplying by the number of bays and adding the end gable framing. A good structural designer can determine this in about 40 hr of work.

Roofing and siding quantities are a matter of simple arithmetic. Note that the roofing in Table I is insulated. If the roof is not insulated, the unit cost of material is essentially the same as for siding, and the cost of installation drops to $0.25 per sq ft. These prices include fasteners, cement, flashing, etc.

Roof drains consist of welded pipe and in many cases a channel gutter, and a conservative price of $400.00 per ton for material and an equal amount for installation will cover costs. Quantities from roof to floor level are easily obtained.

Building ventilation for a steel mill generally requires five to seven changes per hour except where heat processes or special conditions exist. By determining the building volume and air changes necessary, the fan capacity and the number of fans is determined. A fan quotation can then be obtained. The installation cost is in the order of a few hundred dollars if the building steel has been framed properly to take the fans. The electrical wiring costs consist of a combination starter with pushbuttons and is in the order of $300.00 per fan. If a heat process is used or abnormal ventilation is necessary, a monitor type ventilator is used and the cost of these installed is approximately $100.00 per ft for ventilator with a 4-ft wide opening on each side and manually operated dampers.

Well planned ventilating systems require louvers so that enough air can enter the building to permit proper functioning of fans. An efficiency factor of 50 per cent is used in determining the square feet of louver area required. The area of door openings should be considered in establishing louver area. The cost of louvers is approximately $9.00 per sq ft installed.

The cost of doors completely installed for both trucks and railroad is listed in Table I.

Building lighting can be estimated in two ways. First, by taking one bay and estimating material and labor costs times the number of bays. Second, if a 400-watt mercury vapor lamp and 1000-watt incandescent lamp

are used, the installed cost for 20-foot-candle intensity is approximately $0.80 per sq ft. Fluorescent lighting in motor rooms or offices using a good industrial fixture will cost approximately $1.75 per sq ft for a foot-candle intensity of 100.

Material for overhead power feeders in a building for both 440-v alternating current and 250-v direct current can be established by a rough layout of the cable. The big item is, of course, the copper, and since copper prices have varied from $0.23 to $0.52 a lb during the past year, current costs should be obtained for cable. The installation cost, particularly if copper prices are low, will be 150 per cent of material costs.

Building heating like lighting can be determined both by pricing material and adding labor or by using a price of $0.25 per sq ft of building. Since the cost of heating is low, any error will not materially affect your total estimate.

Painting the building steel will cost roughly $10.00 per ton per coat for both material and labor.

Because of its simplicity, nowhere in a project is there so much consistency as in contractor's bids for concrete floors. Note the price in Table I is much lower for concrete floors than for concrete piers. This is true because floors require no excavation and very little form work.

Wood blocks of 2½-in. thick oak, completely installed should cost $6.30 per sq yd.

If additional buildings, such as motor rooms or storage areas, are required, each can be estimated by the method outlined above.

Office, tool room, locker and work rooms, etc., can be estimated at $15.00 to $18.00 per sq ft.

Mill toilets average $9,000 to $10,000 each. This seems high, but experience indicates the cost is generally in this range.

If the plant is to be located at a new site and a general office is required, even a modest office building will cost $300,000.00. Some of the more recent and elaborate general offices have costs of $3,000,000 to $5,000,000. This type of construction is of a commercial nature, and this author is not being familiar with it.

Account No. 8 in Table I lists the cost of some recently installed mill cranes. Crane costs should be checked with the crane builders for any given application. You should not forget the magnets and hooks.

Note in Table I that a 2000-ft 2000-amp crane collector system, using steel rails with a copper booster cable, will cost 30 per cent more than an aluminum collector system. The mechanical erection of the crane is estimated at $150.00 per ton and the electrical installation is worth roughly $5000.00 per crane.

Account No. 9 covers the mill machinery which should be obtained from the mill builders. In the hundreds of mill installations familiar to this author, the changes and additions from the original mill to the ultimately installed mill will add three to five per cent to any original estimate.

The mill erection cost will vary from $50.00 to $100.00 per ton depending on the equipment weight and the amount of assembly work involved.

The electrical equipment and erection of it is about the same story as the mill equipment.

At this point, 60 per cent of the estimate is complete and this part of the job can be done very accurately. The balance of the estimate will require more effort and more judgment on the part of the mill engineer in arriving at accurate costs. The four large items of mill construction are the mill and motor room foundations, the electrical conduit and cable, the interconnecting piping for the mill and the services.

Account No. 13 covers the electrical wiring costs of a mill. If the preparations outlined previously have been made, the material costs can be accurately established. The conduit and cable "take off" can be made by scaling the distance from point of origin to termination of the conduit on a block layout of the motor room and mill area. If cable trays are used instead of conduit, these quantities can also be determined by the same method. A single line layout of the bus on the block diagram can be used to obtain the copper bus quantities. It can be assumed that an insulator will be required for every 3 ft of bus run and that two expansion joints are needed for each bus run.

With the quantities of conduit, bus and cable established, current unit prices are obtained. Conduit and cable trays should be priced by carload lots for projects of the size being discussed. Cable and bus prices should be checked with a cable and bus manufacturer since the price of copper fluctuates violently. After the total cost of these major electrical construction items is determined, approximately 25 per cent of their total should be added for pull boxes, conduit fittings, cable terminals, supports, etc., which are required for installation.

With the material costs now determined, a 60 to 40 per cent labor-to-material ratio can be used to determine labor of installation. This means that material costs must be multiplied by a factor of 1.5 to get labor costs. Judgment should be used here to avoid over or underestimating labor costs. If the job is one in which the installation is simple, labor cost can be reduced to some extent. On the other hand, if the job is a rather difficult one, the labor estimate should be increased.

One may also arrive at electrical installation cost by using a contractor's method of determining the cost of every item in detail and applying labor units. This is a long process which requires reasonably complete electrical layouts. Layout drawings for a similar previous project are often of considerable help if this method is to be used.

Account No. 15 which covers the interconnecting piping, can be estimated by using the same method outlined for the electrical cost. Very useful in establishing lengths and sizes of pipe runs are the flow sheets used on a similar mill. There are not nearly so many changes made in mill piping as in the electrical work from job to job. One should not be alarmed if he finds the valves and fittings for a piping installation costing six to 10 times the cost of the pipe.

Labor costs are usually equal to the cost of pipe and fittings although some engineers like to use a 60 to 40 ratio.

Account No. 16 covers the mill foundations. To establish quantities of concrete for a rolling mill, one can assume that the outline dimensions of the mill represents a solid block of concrete. A factor depending on the type of mill is then used to compensate for the pits and other voids. This factor is approximately 0.8. However, it will vary with each rolling mill and will not be appli-

TABLE I

Sample Cost Estimate

Account Number	Account description	Quantity	Unit price	Estimate	Total
1	Site Preparation				
	a. Slag fill	1,000,000 yd	$ 1.40 yd	$1,400,000.00	
	b. Sand fill	500,000 yd	1.30 yd	650,000.00	
	c. Bulldozing and rolling	1,500,000 yd	0.05 yd	75,000.00	
	d. Relocation of services, piping and electrical underground services	Same data as for new installation (see below)			
	Removal of				
	e. Overhead services	5 per cent of cost of new		10,000.00	
	f. Existing concrete	1,000 yd	80.00 yd	80,000.00	
	g. Hand excavation	(Not often used)	10.00 yd		
	h. Backfill compacted	(If used)	4.00 yd		
	j. Machine excavation	(Sandy soil)	1.50 yd		$ 2,215,000.00
2	Mill Building Foundations				
	a. Bearing piles				
	1. Concrete filled pipe	800 x 90 ft	5.50 ft	363,600.00	
	2. H-piling (100,000 lb)	800 x 20 ft	8.50 ft	(If used)	
	3. Caissons (20-in. shaft)	100 x 20 ft	9.00 ft	(If used)	
	4. Caissons (24-in. shaft)	90 x 20 ft	12.00 ft	(If used)	
	5. Caissons (30-in. shaft)	80 x 20 ft	14.00 ft	(If used)	
	6. Caissons (36-in. shaft)	70 x 20 ft	16.00 ft	(If used)	
	b. Sheet piling				
	1. Material (27 lb per sq ft)	1,000 sq ft	3.25 sq ft	3,250.00	
	2. Driving	1,000 sq ft	1.00 sq ft	1,000.00	
	3. Pulling	1,000 sq ft	1.00 sq ft	1,000.00	368,850.00
	c. Foundations				
	1. Concrete (3,000 lb) (including excavation, forming and backfill)	3,000 yd	70.00	210,000.00	
	2. Rebar material (including bent bars)	200,000 lb	0.08	16,000.00	
	3. Rebar placing	200,000 lb	0.04	8,000.00	
	4. Anchor bolts	25,000 lb	0.25	6,250.00	
	5. Anchor bolt placing	25,000 lb	0.16	4,000.00	
	6. Imbedded steel material	6,000 lb	0.23	1,380.00	
	7. Imbedded steel placing	6,000 lb	0.12	720.00	
	8. Waterproofing grade walls	80,000 sq ft	0.06	4,800.00	251,150.00
3	Building Above Foundations				
	a. Structural steel—designed, detailed, fabricated and erected	6,000,000 lb	0.165	990,000.00	
	b. Roofing material, insulated including flashing, fasteners, etc.	300,000 sq ft	0.90	270,000.00	
	c. Roofing installation	300,000 sq ft	0.50	150,000.00	
	d. Siding material—noninsulated with fasteners, flashing, etc.	250,000 sq ft	0.30	75,000.00	
	e. Siding installation	250,000 sq ft	0.25	62,500.00	
	f. Roof drains				
	1. Gutters	8,000 lb	0.20	1,600.00	
	2. Pipe	12,000 lb	0.20	2,400.00	
	3. Supports	1,000 lb	0.20	200.00	
	g. Roof drain installation			5,000.00	
	h. Roof ventilators (40,000 cfm)	30	1,200.00	36,000.00	
	j. Roof ventilation installation				
	1. Mechanical erection	30	200.00	6,000.00	
	2. Electrical control and wiring	30	300.00	9,000.00	
	k. Doors installed				
	1. Railroad doors (22 ft-6 in. high)	3	2,000.00	6,000.00	
	2. Truck doors (15 ft-0 in. high)	4	1,300.00	5,200.00	
	l. Louvers—material	2,000 sq ft	6.00 sq ft	12,000.00	
	m. Louvers—installation	2,000 sq ft	3.00 sq ft	6,000.00	
	n. Lighting installed (400-watt mercury vapor and 1000-watt incandescent 20-ft-candles)	200,000 sq ft	0.80 sq ft	160,000.00	
	o. Grounding—500 MCM cable	6,000 ft	0.40 ft	2,400.00	
	p. Grounding installation	Cable and ground wells		7,500.00	
	q. Overhead feeders—440-v a-c				
	1. 1000 MCM-1/C cable	15,000 ft	1.40 ft	21,000.00	
	2. 500 MCM-1/C cable	8,000 ft	0.80 ft	6,400.00	
	3. Conduit and fittings (risers)			10,000.00	
	4. Power receptacles and switches	100	85.00	8,500.00	
	r. Overhead feeders—440-v a-c	Installation		65,000.00	
	s. Overhead feeders—250-v d-c				
	1. 1000 MCM-1/C cable	8,000 ft	1.40 ft	11,200.00	
	2. Conduit and fittings			3,000.00	
	t. Installation			21,000.00	
	u. Heating installed	200,000	0.25 sq ft	50,000.00	

TABLE I (continued)

Account Number	Account description	Quantity	Unit Price	Estimate	Total
	v. Painting structural steel	3,000 tons	10.00/ton/coat	30,000.00	
	w. Floors				
	1. Concrete	2,000 yd	23.00 yd	43,000.00	
	2. Rebar (straight)	60,000 lb	0.05 lb	3,000.00	
	3. Rebar placing	60,000 lb	0.04 lb	2,400.00	
	x. Concrete testing			2,000.00	
	y. Wood blocks placed—2½ in. oak	2,000 sq yd	6.30 sq yd	12,600.00	2,095,900.00
4	Motor Room				
	Same procedure as for mill building				350,000.00
5	Office Rooms				
	a. Operating personnel office	1,000 sq ft	18.00 sq ft	18,000.00	
	b. Tool rooms, etc.	1,000 sq ft	18.00 sq ft	18,000.00	36,000.00
6	Mill Toilets	6	10,000.00	60,000.00	60,000.00
7	Main Office in New Plant Site	1	Cost depends on size and type of construction		300,000.00
8	Cranes				
	a. 10-ton (approximate 100-ft span)	Lift and span	140,000.00	140,000.00	
	15-ton (approximate 100-ft span)	determine	155,000.00	155,000.00	
	25-ton (approximate 100-ft span)	crane cost.	185,000.00	185,000.00	
	35-ton (approximate 120-ft span)	Check with	195,000.00	195,000.00	
	50/25-ton (approximate 135-ft span)	supplier	225,000.00	225,000.00	
	75-ton (approximate 90-ft span)		200,000.00	200,000.00	
	b. Crane magnet	4	2,600.00	10,400.00	
	Crane hook	4	4,500.00	17,000.00	
	c. Collector system (steel rails with booster; 2000-ft runway—2000 amperes)	2,000 ft	30.00	60,000.00	
	Aluminum—collector	2,000 ft	20.00	(If used)	
	d. Mechanical erection		150.00 ton	45,000.00	
	e. Electrical switches and conduit with wiring	6	5,000.00	30,000.00	1,262,400.00
9	Mill Machinery	Obtain from mill builder	3,000,000.00	3,000,000.00	
10	Mill Erection	3,000 tons	50 to 100 ton	225,000.00	3,225,000.00
11	Electrical Equipment	Obtain from electrical manufacturer	3,000,000.00	3,000,000.00	
12	Electrical Erection	1,000 tons	100.00 ton	100,000.00	3,100,000.00
13	Electrical Conduit and Wire				
	a. Conduit				
	1. 1½ in.	30,000 ft	0.42 ft	12,600.00	
	2. 2 in.	20,000 ft	0.56 ft	10,200.00	
	3. 3 in.	10,000 ft	1.15 ft	11,500.00	
	4. 4 in.	8,000 ft	1.80 ft	14,400.00	
	b. Wire and cable			200,000.00	
	c. Pull boxes, fittings, etc.			50,000.00	
	d. Bus		0.35/lb	20,000.00	
	e. Insulators and supports	Check supplier		25,000.00	
	f. Installation			450,000.00	
	g. Pulpits			20,000.00	813,700.00
14	Motor Cooling System				
	a. Cleaner and fans	400,000 cfm	0.35 to 0.50/cfm	200,000.00	
	b. Installation			80,000.00	280,000.00
15	Mill Piping				
	a. Pipe		400.00 ton	25,000.00	
	b. Fittings			150,000.00	
	c. Installation			200,000.00	375,000.00
16	Mill Foundations				
	a. Concrete in place	30,000 yd	55.00 (North) 50.00 (South)	1,675,000.00	
	b. Structural beams	100,000 lb	0.12/lb	12,000.00	
	c. Placing beams	100,000 lb	0.025/lb	2,500.00	
	d. Floor plates	250,000 lb	0.15/lb	37,500.00	
	e. Placing floor plates	250,000	0.025/lb	6,250.00	
	f. Mill piling	400	550.00 each	220,000.00	1,953,250.00
17	Pump House	Use same procedure as for mills			200,000.00
18	Roll Shops, Etc.	Use same procedure as for mills			150,000.00
19	Furnace	Use same procedure as for mills			800,000.00
20	Outdoor Substation				
	a. Steel structures galvanize	100,000 lb	0.30/lb	30,000.00	
	b. Foundation	400 yd	100.00 yd	40,000.00	
	c. Grounding (500 MCM)	4,000	0.40 ft	1,600.00	

TABLE I (continued)

Account Number	Account description	Quantity	Unit price	Estimate	Total
	d. Install grounding			1,600.00	
	e. Equipment	Check supplier		300,000.00	
	f. Fence	800	2.50 ft	2,000.00	
	g. Gates	20 ft	10.00 ft	200.00	
	h. Equipment placing			8,000.00	
	j. Conduit and wire installed			50,000.00	433,400.00
21	Power Transmission				
	a. Underground duct systems				
	1. Concrete	3,000 yd	60.00 yd	180,000.00	
	2. Rebar—material	15,000 lb	0.05/lb	750.00	
	3. Rebar—installation	15,000 lb	0.04/lb	600.00	
	4. Manhole cover and miscellaneous steel inserts			10,000.00	
	5. Duct—4 in.	300,000 ft	0.27 ft	81,000.00	
	6. Cable	50,000 ft	5.00 ft	250,000.00	
	7. Miscellaneous splice kits and hardware			40,000.00	
	8. Installation of cable and duct			400,000.00	
	9. Grounding			3,000.00	965,350.00
	b. Overhead power distribution—400-v a-c and 250-v d-c				
	c. Cable—1000 MCM	10,000 ft	1.40 ft	14,000.00	
	d. Cable supports and fittings			3,000.00	
	e. Installation			15,500.00	32,500.00
22	Grounding				
	a. Cable—500 MCM	20,000 ft	0.25 ft	2,500.00	
	b. Ground wells	10	500.00 each	5,000.00	
	c. Connectors	200	5.00 each	1,000.00	
	d. Installation			9,000.00	17,500.00
23	Yard Lighting	Same as building lighting			50,000.00
24	Telephone				
	a. Bell system				
	1. Conduit—2 in. diam	1,000 ft	0.56 ft	560.00	
	2. Boxes	10	50.00 each	500.00	
	3. Fittings			200.00	
	4. Installation			1,500.00	
	b. PX system			60,000.00	62,760.00
25	Service Piping				
	a. Service water				
	1. Pumps, motors and control	From supplier		10,000.00	
	2. Foundations	Same detail as for mill		7,000.00	
	3. Pipe and valves			70,000.00	
	4. Installation			80,000.00	
	5. Water strainer			20,000.00	187,000.00
26	Coke-Oven Gas	Same methods as for service water			100,000.00
27	Steam Service Lines	Same as for service water			200,000.00
28	Drinking or City Water	Same as for service water			20,000.00
29	Compressed Air				
	a. Pump house foundations and equipment foundations	Same detail as for mill foundations		75,000.00	
	b. Building above foundations			58,000.00	
	c. Compressors			120,000.00	
	d. Electric motors and control			50,000.00	
	e. Mechanical and electrical erection			68,000.00	
	f. Pipe and valves			70,000.00	
	g. Pipe installation			70,000.00	511,000.00
30	Fire Protection	Use same detail as for compressed air			150,000.00
31	Main Sewers				
	a. Concrete pipe			60,000.00	
	b. Other material and manholes			20,000.00	
	c. Installation			90,000.00	170,000.00
32	Sanitary Sewers	Same method as for main sewers			130,000.00
33	Railroad Track System				
	a. Standard gage railroad tracks, including rails (105-lb), frogs, ties, splices, spikes, bolts and road bed installed	30,000 ft	18.00 ft	540,000.00	540,000.00
34	Roadways (macadam)	20,000 sq yd	5.00 sq yd		100,000.00
35	Miscellaneous Equipment and Other Costs				

TABLE I (continued)

Account Number	Account description	Quantity	Unit price	Estimate	Total
	a. Locomotives			120,000.00	
	b. Track scales and house			100,000.00	
	c. Walkways			20,000.00	
	d. Unloading			150,000.00	
	e. Storage			100,000.00	
	f. Construction office			25,000.00	
	Temporary services			150,000.00	
	h. Well pointing				
	1. Pumps		7,000/pump/month	84,000.00	
	2. Operation and maintenance		100 day	200,000.00	
	3. Initial cost			100,000.00	
	j. Property fence				
	1. Fence	10,000 ft	2.50 ft	25,000.00	
	2. Gates	30 ft	10.00 ft	300.00	1,074,300.00
36	Engineering				
	a. Installation engineering—design and drawings		1½ to 2 per cent project cost	500,000.00	
	b. Field surveying and field engineering and material		⅓ of design cost	150,000.00	
	c. Testing boring and soil mechanics			5,000.00	
	d. Engineering supplies			10,000.00	665,000.00
37	Labor and Material Escalation		5 per cent		1,000,000.00
38	Premium pay		10 per cent of labor cost		400,000.00
39	Contingencies		3 per cent		600,000.00
				Grand Total	$25,245,060.00

cable to process lines in which a tub designed is used for foundations. In estimating concrete quantities for a process line, a cross section of the tub is sketched and quantities established from it. The more knowledge and experience the civil engineer has, the more accurate his quantities will be. Note that in Account No. 16, a unit price per yard of concrete was used and that there is a differential between areas which can vary from $5.00 to $15.00 per cu yd. The unit price per cu yd includes all the items used to estimate cost of foundations for the building piers.

A cubic yard of concrete in a rolling mill will require approximately 11 to 12 sq ft of forming because of the large mass. In building piers and grade walls, some 30 to 40 sq ft or more of forming is needed per yard. Since form work costs from $0.54 to $1.50 per sq ft the price of a cubic yard of concrete will vary accordingly.

Structural beams over oil cellars or basements can easily be sized and spaced by a civil engineer. Weights and costs are as indicated in Table I. The same facts apply to floor plates around the mill.

Construction costs for pump houses, roll shops, furnaces and other auxiliary components are arrived at by the same procedures as outlined above.

Outdoor sub-station costs can be estimated as indicated on Account No. 20 of Table I. It does not take much of a sub-station to reach $500,000 in cost.

Account No. 21 covers the power transmission which, in modern mills, is usually underground. A plant map, even on a large project, will enable one to route duct runs with accuracy. Lengths of runs, number and size of ducts, cable lengths and the number of manholes can be obtained from a simple layout. Manhole costs can be found by using the same method outlined above for concrete work. If pea gravel concrete is used in the duct run, the cost per cubic yard of concrete poured will be higher than for mill foundation where a coarse aggregate is used. High voltage cable is expensive and lengths should be taken off accurately. Current prices should be checked for the type of cable to be used. If single conductor cable is used, grounding will be a special problem and the cost of it will be appreciably higher.

Low voltage distribution, equipment grounding and yard lighting can be priced by simple layouts using the methods outlined above. The telephone costs are low, requiring only conduit and junction boxes, if a Bell system only is used. A PX or plant telephone system will, of course, cost considerably more and its cost will vary with size. Manufacturers of these systems will provide information for estimating purposes.

For service piping, water piping, sewers, etc., a simple layout made on a plant map will provide material quantities for pricing. Installation costs will be equal to material costs.

Item No. 33 covers the plant railroad track system which again can be sketched on a plant map to determine length of track required. If a unit price of $18.00 per ft is used, it will cover the rails, ties, roadbed, splices, frogs, turnouts, etc.

Roadways can be sketched on a plant map and will usually cost $5.00 per sq yd of area installed for "black top" or "macadam." If concrete roadways are used, these can be priced as outlined for mill floors.

Account No. 35 covers miscellaneous construction costs often forgotten. Nevertheless, they amount to a considerable sum of money. Approximate costs for these are listed in this account.

Construction engineering will vary by considerable amounts depending on the flow of information and conditions under which engineering must proceed. In no other phase of the job is the cost so dependent on the stature of the project director. Variations of 100 per cent are not uncommon for identical projects.

Item No. 37 covers labor and material escalation. Since World War II, escalation has increased construction costs approximately five per cent each year. Price escalation has caused more error in estimates over the past 15 years than any other single item.

In the first place, it is generally overlooked. The fine print on contracts generally covers escalation. Most mill builders use the government current business index. However, this is not always the case, and a sample contract should be read carefully, if an accurate cost estimate is to be made. Electrical equipment is usually quoted at a firm price and on a functional basis, except during national emergencies. All other phases of a construction project will usually be subject to escalation. A good construction schedule is required if an accurate estimate is to be made on a large program which will extend over several years. Since some of the project may be completed in several years the escalation during the second year may be 10 per cent of the original estimate instead of five per cent.

Item No. 38 covers premium pay for construction labor. At the beginning of a new project, everyone vows there will be no overtime on the project. However, long before the program is half complete, many reasons will cause one to break these honest vows. Overtime should be included in any estimate; and if your management prohibits it, hide the cost in other hard to check items, for it will occur regardless of efforts to prevent it.

The last account is, of course, contingencies. Management will take a long, hard look at this item. What are contingencies? They are real events, happenings or late discoveries which cannot be foreseen and their costs are as real as the cost of the mechanical equipment or the building. A contingency cost is a cost item that will occur, has always occurred in every construction job and will always occur on any contemplated construction. The only difference between these costs and the cost of the mill, the building or any other item of an estimate is that although it exists, one cannot pinpoint it exactly. Excavation may reveal soil conditions in a large area not known to exist or not revealed by soil tests which requires additional concrete pours; a labor strike may extend the project schedules, weather may be adverse, or many other unforeseen events may occur. These are the costs intended to be covered by contingencies.

This completes a typical cost estimate, but many questions remain unanswered.

ACCURACY

The first question is "how accurate are estimates made by this method?" Accuracy, of course, depends on the effort put into the job, the amount of detail investigation, the experience of the people involved and perhaps other factors. Errors of omission are generally more fatal than errors of commission. Compensating errors will occur if you consider the whole job, even if someone can prove any item in a breakdown to be in error.

Many estimates made by this method have been done to an accuracy of better than one per cent. One must, however, remember that statistics can be put on paper, but the estimator's ability cannot. Moreover, the engineer directing the project can undo the best of cost estimates by improper administration of the job. Therefore, if enough time, effort, experience and a good sense of value is put into a cost estimate, it can be used effectively as a part of cost control in a project where contracts are let on a unit price.

SIGN POSTS

Since the road along which an estimator must travel is often dark and strewn with many pitfalls, let us put up some sign posts and light some of the lamps along the road.

These data can be used as a guide for typical plant projects and often prevent one from making a major error or drifting too far afield. They can also be used as a quick estimate.

The typical steel mill building should average $16.00 per square foot of floor area if no piling is required and $18.00 per square foot if piling is required. Included in these figures are the roofing, siding, structural steel, lighting, crane rails (not collector rails), building piers, grade walls, doors, louvers, depressed tracks, building grounding, roof drains, roof ventilators, heating and floors all completely erected and ready for operation.

An average crane erected with collector system for a metal working mill will cost somewhere near $200,000.00.

If a breakdown of major items is required, the following will be a good guide:

1. Concrete per cubic yard in place—$55.00 as a complete plant average ($50.00 in South).
2. Concrete per cubic yard in place for building piers and grade walls—$90.00.
3. Concrete per cubic yard for floors—$25.00.
4. Building steel erected and painted—$350.00 per ton.
5. Bearing piles and sheet piling as listed in Table I, Account No. 2.
6. Lighting (using mercury vapor and incandescent lamps)—$0.80 per sq ft of floor area.

The electrical material and installation costs for some typical mills are as follows:

1. High-speed tandem cold reduction mills, $400,000.00 per stand. This also applies to temper mills.
2. Large, modern blooming mills, with more than 10,000 hp on main drives will cost about $1,500,000.00.
3. Large, modern bar mills—$2,250,000.00.
4. Multiple strand rod mills—$1,250,000.00.
5. Hot strip mills—$350,000.00 for each finishing stand and $500,000.00 for each roughing stand.
6. Modern seamless tube mill—$1,800,000.00.
7. Processing lines and auxiliary mills—Vary too much in size and application that the available information could only be misleading. Costs of the electrical installation also changes appreciably by the various locations of the electrical control and other electrical equipment.

Piping is somewhat like the electrical and can vary considerably depending on equipment location. However, some typical guides are listed below:

1. Modern high-speed tandem cold mill—$100,000.00 per stand.
2. Large blooming mill complete with shear and table—$375,000.00.
3. Large continuous hot strip mill-approximately $100,000.00 per stand.

4. Seamless mill complete with finishing end—$500,000.00.
5. Pickling line—$225,000.00.
6. Cleaning line—$100,000.00.
7. Tinning lines vary so much by type and equipment location that information would be misleading.
8. Tin plate shearing line—$60,000.00.
9. Side trim and recoil line—$30,000.00.
10. Labor on piping installations will vary from 60 to 80 per cent of the material cost. This happens because many of the more expensive valves and sometimes the process piping are furnished as part of the mill or line, but must still be installed by the contractor.

Foundations for the mills only will vary with conditions. However, some guide posts should be set up for mill foundations.

1. High-speed tandem mills—$120.000,00 per stand.
2. Blooming mill—$2,000,000.00.
3. Seamless mill—$2,250,000.00.
4. Hot strip mill—finishing stands—$125,000.00 per stand.
   —roughing stands—$300,000.00 per stand.
   (All of the above includes coilers, tables, motors, scarfers, shears and other equipment normally a part of the mill.)

Since other types of mills and process lines are likely to vary with size and arrangement of equipment, basements, etc., data on these will be withheld. Moreover, the quantities of concrete for mill foundations can be determined accurately and with little effort from the mill general arrangements.

Electrical power transmission will generally cost about two per cent of the total project cost and the substation will approximate one per cent of the project cost.

Other items to be used as guide posts can be obtained from Table I.

TYPES OF CONTRACTS

Construction contracts for mill erections are of many varieties and the type let often depends on economic conditions at the time. Most mills prefer, if possible, to complete engineering and obtain firm lump sum prices. For the past 20 years this has not always, in fact not often, been possible. Many substitutions have been made from this long established practice; some are good, others are not too satisfactory.

In this author's experience, the unit price contract is, by far, the best and perhaps even better than the firm lump sum contract.

It offers the advantage of:

1. Being competitive. That is, many contractors could be called upon to submit bids.
2. Ease of control. If properly set up with a good set of engineering drawings and a good cost estimate, it is by far the easiest to administer.
3. Not requiring a contractor to add 10 per cent for profit, 10 per cent for bad luck and 10 percent for good luck to his price as would be required in a lump sum bid.
4. Paying the contractor for what he does and only for what he does.
5. The customer paying for what he gets and only that.
6. Being applicable to all phases of construction; the structural steel, the roofing and siding, the foundations, the services, the mill erection, and although not to this author's knowledge tried, to the electrical and piping. There is no reason for not letting electrical and piping contracts on a unit price basis. Present electrical practice is to use only five different conduit sizes and to limit the types and sizes of cable to be used. Conduit as well as piping could be let on a unit price per ton. Most contractors will prepare bids by estimating the material for each conduit run and apply labor units to the material for a price on each run. The same holds for piping.

Firm price lump sum contracts are also a satisfactory method of placing contracts, but this method has two distinct and important disadvantages. First, it requires reasonably complete engineering, causing some delay in getting the job started; second, the contractor must take the risk and will charge you for it. To these, one may add the disadvantage of defining accurately the scope of the job. Many differences of opinion in interpreting the scope often arise. The negotiation of the extra charges usually requires more effort and inconvenience than the administration of a unit price job.

The cost-plus-a-fixed or variable fee contract has many more important disadvantages than merits. The chief disadvantage comes in the lack of incentive on the part of the contractor. Occasionally, a bonus is added to this type of contract for completion of the job at a cost less than the estimated figure.

The above types of contracts are mentioned to illustrate the importance of a good accurate early cost estimate.

COST REDUCTIONS

Keeping costs down on a major program is very important since even a small percentage of savings amounts to a large sum of money. Let us briefly consider some of the major pitfalls which run costs up beyond estimates. An overrun on job costs is not always the fault of the estimator. More often than not, the fault is in one of the considerations listed below:

1. *Project director*—No organization or any of its activities is any bigger or any better in any respect than the man who runs it. It is, therefore, imperative that the project director be as big as the job itself.

No engineer, however broad his experience and training, could possibly be thoroughly versed in all phases of a major mill expansion program. Being a good engineer is not the most important consideration in managing new construction. The mill builder, the electrical manufacturer, the engineers, the contractors and other suppliers will do a good job technically. If left to their own devices, they may even do a better job than when they have too much interference.

The paramount consideration, then, in selecting a

director is that he be one who is able to plan, organize and execute the job. If the manager lacks this ability, invariably planning becomes day dreaming, organization becomes confusion and execution becomes persecution of the suppliers. If this unfortunate situation exists, and it often does, the construction costs will increase by 10 to 25 per cent. No single item is so expensive on a construction job as poor direction.

2. *Timing*—The steel market and sales will often determine the time at which a proposed program is executed. However, if it can be planned and completed at a time when there is a minimum of other work in an area and when competitive conditions are keen, considerable savings may be effected.

3. *Engineering*—Good engineering will always reduce construction costs by 10 per cent. Unfortunately, these savings are not always apparent. Many are buried and forgotten. There are always many ways on a large program to do many of the job components. Some are more expensive and yet offer no increase in quality.

4. *Do not do it yourself*—"Do It Yourself" projects are fine if one is working in his own basement for pleasure. However, on a large industrial program, labor and engineering costs of construction work will be at least 25 per cent higher than if done by outside contractors.

5. *Turn key job*—Turn key jobs should be avoided, if at all possible. The cascading of contracts is always undesirable and very costly. Let us assume that a turn key job has been let requiring several tiers of contractors. If the cost of the material and labor is assumed to be $1.00 and the first tier contractor adds a profit of 10 per cent, the cost becomes $1.10. The second tier contractor will add an additional 10 per cent which brings the cost to $1.21. The third or top tier adds another 10 per cent and the cost is now $1.33.

Thus, $0.23 out of each dollar spent is unnecessary expense which adds nothing at all to the value of the end product. If you multiply this by $100,000,000.00 to cover a large project, then the cost of pyramiding would be $23,000,000.00. This is a large sum of money to pay out when you get absolutely nothing in return.

6. *Technical*—Technical means of keeping project costs down are almost too numerous to mention. Let us, however, briefly state some of the more common and more important ones.

a. Column spacing always has an optimum distance. The curve for this is shown in Figure 1. Note that it is a parabola. There will, therefore, always be two spacings which provide equal construction costs and only one that will provide one optimum cost. If extensive piling is used, the curve shifts to the right as shown by the dash or broken line.

b. Insulated roofing or siding is difficult to justify unless the process requires it. Costs of insulation doubles the costs of roofing and siding.

c. Building dimensions should be determined with care. This is also true of the height of the building.

d. In purchasing the mill, one of the proper size and speed for the end product desired should be chosen. Often a mill can be purchased which is a duplicate of a recent mill and the cost of drawings and patterns can be saved.

e. Electrical equipment, likewise, should be properly sized. Rubber or synthetic cable can often be used instead of lead-covered cable and cable trays instead of conduit, where feasible. Field fabrication of bus is generally less costly than factory-fabricated bus. The use of alternating current instead of direct current is generally economical. The use of standard equipment with standard ratings is also worth much consideration.

One of the most important and often overlooked savings on a major expansion program is the consideration of getting the mill in operation as soon as possible. A modern mill of any consequence will earn $25,000 to $50,000 per day. On a 5-day week, this would amount to more than $5,000,000.00 in a 6-month period. Many sins of construction can be overlooked profitably, if they get the mill in operation sooner and there is, we hope, a market for the end product.

There is no end of the ways in which savings can be accomplished, so let us just classify them under good engineering and good administration.

SUMMARY

In summation, let us say that a cost estimate well within acceptable accuracy can be made. Proper preparation and a considerable effort on the part of a group of people is required. The estimate will then be as accurate as the abilities of the people involved. Statistics can be specific and tabulated but the sense of values, sense of proportion and general knowledge of the estimator and the abilities of the director of the job must remain intangible. All will affect the end result. No estimator can do an accurate job of estimating unless he can control the engineering decisions which affect the final cost. In those organizations where the project direction and the estimating is done by the same group, the probability of costs exceeding the estimate are diminished. This is particularly true if the project director has a broad background in plant expansion and is a good planner as well as a good organizer. Engineering errors are usually of a minor nature and seldom expensive. The costly errors which throw estimates out of line are invariably made in the management of the program.

It is also well to remember that the estimator should always slightly overestimate rather than underestimate. It is impossible to estimate the exact cost. Therefore, some difference in the estimate and actual cost will exist. The question is: "How much?"

Discussion

PRESENTED BY

E. J. VALONIS, Shape Products Engineer, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

D. K. WARD, General Industry Service Station, Engineering & Service Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

E. J. Valonis: I would like to point out a few specific things that I believe would be of interest and value to both estimators and project engineers.

1. Establish the scope as soon as possible. Make

it as complete as possible. Consult with your operating, maintenance and service groups in order to do so. Keep meeting with them frequently during the planning and engineering phases of the job. The scope will determine the accuracy of the estimate as well as the correct ultimate job.

2. Do not forget your repair facilities.

3. Do not forget waste disposal. Above all, do not attempt to over-simplify this phase.

4. Do not assume that just because it is there that it can be used. For example, sewers are easily overloaded.

5. Do not forget mill cleanliness. Quite often elaborate foundation features are needed that change the unit costs of these foundations.

6. Plan your crane capacities large enough to take care of magnets and other handling devices.

It would not take too much imagination to discuss these few points for several hours. In mentioning them, I have attempted to show major areas that are often overlooked or minimized. Careful attention to these points will go far towards insuring accurate estimates.

D. K. Ward: There are a couple of points I would like to emphasize. The author has indicated very strongly that time spent on engineering during the estimating stage is very helpful and necessary to arrive at a construction estimate. In view of this statement, I would like to emphasize more strongly the importance of adequate engineering and preestimate planning.

We have found that of all the reasons an estimate is exceeded three definitely stand out. They are:

1. The omission of work by the estimator. This was thoroughly discussed by the author.

2. The increase in labor costs prior to and during construction.

3. The underestimating of the construction time required on a project.

Numbers 2 and 3 are two variables over which complete control cannot be exercised. While the over-all labor costs are dependent on many variables, they are a direct function of the time spent on the project and hence are related thereto.

In many cases, the labor cost increase and the efficiency of labor can be predicted with a considerable degree of accuracy by referring to past records and determining the labor rate increases and the delays caused by labor disputes and other delays linked directly to labor efficiency. There is however a type of job where it is extremely hard to estimate with any accuracy the completion time or the labor cost increases. This type of project is one that is situated in what may be referred to as a "remote area." This "remote area" is one in which there has been no large project previously undertaken and is located in an area where no large labor pool exists. The problem of estimating labor costs and completion dates will now be increased.

First the labor rates in the area are undoubtedly lower than those encountered in other localities where large expansion programs have or are being undertaken and where an adequate labor force is available.

It is possible on remote projects that the labor costs incurred during the final stages of the project may exceed those encountered in areas where the labor costs can be estimated relatively accurate because of past or current projects. All of which lead to a more or less predictable labor cost.

A reason for this higher labor cost is that of insufficient labor plus the necessity of importing labor from other localities.

In a "remote area," such as the one cited, the local available labor force generally must be employed before outside labor can be imported. Since we now have both the local and imported labor factions employed, the labor rates will increase to approximate those in localities where large labor pools exist. In addition to the increase in labor rates, it will be found that benefits paid the labor force as a whole will increase to the extent that they exceed the benefits in other areas. These benefits will in time consist of those paid in other localities, from whence the imported labor came, plus, in many cases, a substantial travel allowance. These benefits will be paid to both local and imported labor thereby increasing total labor costs.

Second, the completion dates will be adversely affected by the inexperienced labor which will be employed on the project.

Since the total labor costs are dependent on high rates, benefits and the total construction time, it is imperative that a thorough study along these lines be undertaken by the estimator. It is imperative that the estimator study all available information from other jobs that have been undertaken in "remote areas." ▲

1960 AISE
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Auspices of Rolling Mill Committee

April 25, 26, 27

Sheraton Hotel

Philadelphia, Pa.

. . . . ten months after initiation of a preventive maintenance program on a hot strip mill, downtime due to mechanical failures was reduced by 76 per cent . . . .

Organizing A Steel Plant Preventive Maintenance Program

by Richard F. Armitage,
General Superintendent
Warren District
Republic Steel Corp.,
Warren, Ohio

PROBABLY no other term has been so widely used or prolificly defined and described in recent times as preventive maintenance. It has provided the theme for a whole host of authors to expound upon, and much of great value and practical application has resulted. It is in a spirit of humility, therefore, that this exposition is added to the list.

Some 24 years ago, the writer first came under the influence of a master mechanic who had the foresight, rare for that era, to visualize the need of a new concept of steel plant maintenance. He simply summed up his philosophy in an oft repeated remark that "repairs are necessary because maintenance has been neglected." Dressed up with the addition of the word preventive, this remark still states the case very well.

The keystone of any successful preventive maintenance program is an adequate and systematic inspection procedure. With this in mind the program described in this paper started some 10 years ago with the development of such an inspection system. It was decided to start the program in the 42-in. hot strip mill, a key production unit of the Warren District of Republic Steel Corp.

The millwright group leaders on each turn had been communicating by note with the general millwright foreman, describing the troubles they had encountered on their turn. This consisted almost entirely of reports of something that had caused delays—in other words, something that *had* happened and which they had corrected in too many cases only well enough to get by with temporarily so as to get the mill back in operation again.

The first step taken was to broaden this coverage to include reports of conditions that had not yet resulted in delays but which if left unattended soon would do so, e.g., worn bearings, poorly meshing and worn gears, worn coupling boxes and spindles, sloppy fit of roll chocks in housings, damaged or worn oil and grease seals, etc.

Simultaneously, much emphasis was placed on their responsibility for keeping all components of the machinery securely fastened by keeping cap and anchor bolts tight on bearings, pinions, mill housings, etc. The objective here was not alone to accomplish these things but to create greater awareness on the part of the mechanical personnel of the importance of avoiding serious trouble by prior notice of and attention to such details. By means of this supplement to his own daily observations and those conditions reported to him by the operators, the millwright foreman was able to do a more effective job of planning his "repair day" effort.

A check list was then compiled listing all major mill equipment in chronological order of its use in the processing, e.g. furnaces, tables, roll trains, drives, etc. Each such main division was further subdivided into its principal components. Under furnaces, for instance, were listed such auxiliaries as slab holders, pushers, skids, piping, chill boxes, etc. This information was listed on a form suitable for use by the inspector in recording his findings as to the condition of the components listed. This was called the Preventive Maintenance Worksheet, a copy of a portion of which is shown in Figure 1. By using the legend shown for marking, together with appropriate and brief explanatory remarks, a very comprehensive picture of the condition of all the important equipment in this or any unit can be recorded.

To get this inspection program going, a shop machinist with considerable field experience was assigned to do the inspection work. Before starting the assignment, he and the mechanical foreman of the unit were carefully briefed as to the purpose of the program and

Sheet No. 1 of 5

PREVENTIVE MAINTENANCE INSPECTION
WORKSHEET
#1 HOT STRIP

District:
Plant:
Date:
Date Prev. Insp.

Legend for Marking: ___O.K. _X_ Repair Req'd. _XX_ Replacement Req'd.
_L_ Lub. Req'd. _A_ Adjustment Req'd.

Note: All Entries Other Than (___O.K.) to be Explained on Reverse Side Under Remarks. Be Sure Number of Item to Which Remark Applies to is Indicated.

	1	2	3
Furnaces: (D)			
1-Slab Holders			
2-Quimby Screw Pumps			
3-Pushers			
4-Skids			
5-Piping			
6-Chill Boxes			
7-Doors and Frames			
8-Dampers			
9-Damper Mechanisms			
10-Discharge Doors & Chains			
11-Mixing Sta. Blowers			
12-Furnace Fans			
13-Structural (Buckstays, Tie Rod, Platforms, etc.)			
14-			
15-			
Table A: (M)			
16-Girders			
17-Pillow Blocks & Brgs.			
18-Lineshafts			
19-Lineshaft Gears			
20-Lineshaft Brgs.			
21-Lineshaft Couplings			
22-Table Rolls			
23-Table Rolls Gears			
24-Drives			
25-Spreaders			
26-Bumpers			
27-			
28-			
Scale Breaker: (D)			
29-Housing			
30-Housing Shoes & Bolts			
31-Windows & Liners			
32-Mill Spindles & Boxes			
33-Spindle Carrier			
34-Screws & Nuts			
35-Spacer & Rod			
36-			
37-			
Scale Breaker Drive: (D)			
38-Falk Reducer			
39-Fast Coupling			
40-Leadshaft & Couplings			
41-Leadshaft Bearings			
42-Lead Spindle & Boxes			
43-Pinion Housing & Cap			
44-Pinion Housing Shoes & Bolts			
45-Pinion Bearings			
46-			
47-			
Feeder Roll Table - Entry #1 RM (Sprocket Drive): (D)			
48-Girder			
49-Driveshaft & Coupling			
50-Worm Gear Reducer			
51-Pillow Blocks & Brgs.			
52-Table Rollers (2)			
53-Sprockets & Chains			
54-			
55-			
Skew Table: (D)			
56-Girders			
57-Lineshaft			
58-Lineshaft Gears			
59-Lineshaft Couplings			
60-Lineshaft Brgs.			
61-Drive			
62-Table Rollers			
63-Table Roller Brgs.			
64-Table Castings			
65-Table Roller Gears			
66-			
67-			

Edgers - Nos. 1, 2 & 3: (W)	1	2	3
68-Drives			
69-Spindles & Carriers			
70-Driveshafts			
71-Bevel Drive Gears			
72-Pinions			
73-Pinion Brgs. (Roller Type)			
74-Housings & Gibs			
75-Edger Rolls			
76-Positioning Device			
77-Lubricators			
78-Foundations			
79-			
80-			
Tables B & C: (D)			
81-Girders			
82-Drive			
83-Lineshafts			
84-Lineshaft Gears			
85-Lineshaft Brgs.			
86-Table Rolls			
87-Table Roll Brgs.			
88-Table Roll Gears			
89-Table Castings			

mvw

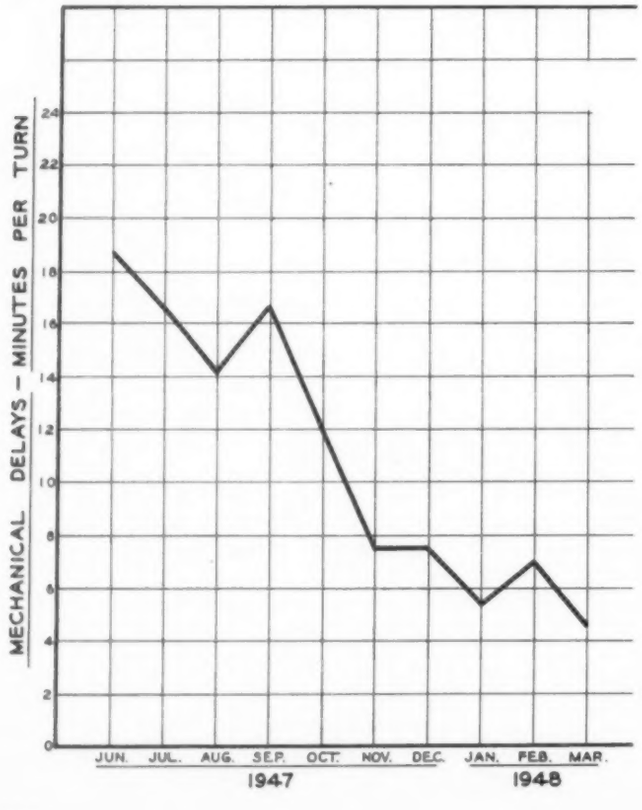
Figure 1 — Millwright group leaders were required to complete this form every turn.

the procedures to be followed. Initially, the complete reports were submitted to the mechanical and operating superintendents and the mechanical foreman twice a month and all concerned, including the inspector, helped to coordinate, plan and execute the corrective measures indicated necessary. At this same time, operating turns were reduced from 20 to 19 on this unit, allowing an extra eight hours of repair time each week. Through careful planning, much valuable work was accomplished during down periods for roll changes or any other delays on the mill. Progress was measured in terms of reduction in delay time. At the start of the program, this unit was averaging 18.7 minutes per turn mechanical delays, or approximately 4 per cent of crew time. Ten months after the program was started, this had been reduced to 4.6 minutes per turn, or 0.96 per cent of crew time. A chart showing the steadily downward trend is shown in Figure 2.

The resultant improved equipment condition and performance permitted the frequency rate for submission of inspection reports to be lowered and the responsibility for the whole program, including inspections, was gradually transferred to the departmental mechanical foreman. This relieved the inspector to initiate similar programs in other operating units.

It should be mentioned at this time that much of the success of such a program, particularly in its initial stages, depends upon the proper selection of the individual assigned to the inspection work. This man must not only have the prerequisite of mechanical aptitude but must also possess such characteristics as patience, persistence, adaptability and initiative. The best inspection routine half heartedly executed is worse than none at all.

Figure 2 — A preventive maintenance program reduced mechanical delays.



Today such inspections are made by the mechanical foremen throughout the district and submitted according to the perpetual schedule shown in Figure 3.

By staggering the report submission periods as shown, the mechanical department superintendent and his staff have the time and opportunity to evaluate their contents with the submitting foreman and are able thereby to correlate the corrective measures to be employed with those already determined, by the same means, to be necessary in other operating units. To further assist them in this phase of the work, the foreman must earmark the more critical problems identifying them in a special manner in the remarks section of his report.

Normal accounting procedures are used in the followup measures required by the inspection findings. Written job orders are issued to the shops and crafts concerned after authorization by the department superintendent involved. All labor and materials used are charged against this order, thus making it possible to isolate any accruing costs by machinery component, if desirable to do so.

As an adjunct to the procedure just described, a systematic use of nondestructive testing was begun and integrated into the inspection program. Sight and sound methods, even when employed by the keenest and most experienced inspectors, will seldom disclose the internal defects resulting from fatigue of highly and repeatedly stressed shafts, pinions, roll wobbles, spindles, etc. To assist in detecting such flaws before they result in serious breakdowns, an ultrasonic device is used. The periodic checking of vital machinery elements with this device is an indispensible part of any well organized program. Not only does it reduce major and costly breakdowns and insure the readiness of spare parts as required, but it also serves as an important tool in studying and eliminating the causes of repetitive failures or high parts mortality by improved design and manufacturing techniques. A special report form shown in Figure 4 is used to record data collected during such tests for study and reference. Testing for defects in tanks, receivers, pipe, etc., is accomplished by a similar instrument, a sound wave unit. Magnetic particle and penetrant dye methods are also used where applicable.

Another feature of this program which has proved most helpful has been the activity of a so-called "preventive maintenance committee." This group consists of the assistant superintendent of the mechanical department as chairman, the district lubrication engineer, the machine shop foreman, and one representative from the electrical, metallurgical, engineering and industrial engineering departments. The purpose of the committee is to make recommendations to reduce delays and prolong the life of machinery components through a systematic study of the design, materials, lubrication and operation of the various operating units. By this means, they regularly utilize their knowledge of such important fundamentals as surface finish, fillet radii, interference fits, alloy steel selection, heat treatment, etc. In addition to the projects selected by their chairman from his daily analysis of operating unit performance, all maintenance and operating personnel in the district are free to and do solicit help from this group. This committee meets as often as the problems being studied require, but in no case less than once a

WARREN	Mo.	JAN				MAY				SEPT.			
	Wk.	1	2	3	4	1	2	3	4	1	2	3	4
COKE PL.			X										
BLAST FC.					X								
BLOOM. M.							X						
#1 H.S.									X				
#2 H.S.											X		
#3 H.S.													
H.S.F.													
COLD STRIP													

WARREN	Mo.	FEB.				JUNE				OCT.			
	Wk.	1	2	3	4	1	2	3	4	1	2	3	4
COKE PL.													
BLAST FC.													
BLOOM. M.													
#1 H.S.													
#2 H.S.													
#3 H.S.													
H.S.F.											X		
COLD STRIP													X

WARREN	Mo.	MAR.				JULY				NOV.			
	Wk.	1	2	3	4	1	2	3	4	1	2	3	4
COKE PL.													
BLAST FC.													
BLOOM. M.													
#1 H.S.													
#2 H.S.							X						
#3 H.S.											X		
H.S.F.													
COLD STRIP													

WARREN	Mo.	APR.				AUG.				DEC.			
	Wk.	1	2	3	4	1	2	3	4	1	2	3	4
COKE PL.													
BLAST FC.													
BLOOM. M.													
#1 H.S.													
#2 H.S.													
#3 H.S.													
H.S.F.													
COLD STRIP													X

Figure 3 — The mechanical foremen's reports to the mechanical department superintendent in accordance with this schedule give sufficient time to correlate corrective measures.

week. Their deliberations and findings are carefully recorded and distributed to all concerned and filed and cross referenced in the committee library so as to constitute a ready reference for possible future use. This group has to their credit solutions to many problems previously accepted as necessary evils to be tolerated and lived with.

As a final feature of this program, a concerted effort has been and is still under way to intelligently acquire, properly store and control spare parts. A policy of decentralization in this regard again gives the department superintendent and the departmental mechanical foreman the key roles to play. These people possess the best knowledge of the critical areas of their operating units and by virtue of this are best qualified to determine what spares they need to insure continuity of operations.

Figure 4 — This form is used to record results of ultrasonic gage tests.

REFLECTOSCOPE TESTS
WARREN DISTRICT

DATE_____

TEST #_____ DEPARTMENT _____ TESTED AT _____

TESTED BY _____ PART NAME _____ DWG NO. _____

PURPOSE:

SKETCH:

PROCEDURE:

Crystal Frequency _____ Type Crystal _____ Range _____ Sensitivity_____

RESULTS & CONCLUSIONS:

FOLLOW-UP:

The mechanical foreman is required to provide facilities for and store in an orderly manner all such parts and to record and keep current the information shown on the Inventory Record Card shown in Figure 5. It is felt that by the proper keeping and evaluation of such records, attention is focused on high mortality areas which need special study and much valuable information as to the relative merits of different designs, types and makes of parts and materials can be acquired. Admittedly, this is the most difficult phase of the program to get executed properly. Facilities for the proper segregation and storage of the many parts involved are often inadequate and the instinct to hoard bad order parts, "just in case," serves to aggravate this problem. Mill maintenance personnel are notoriously poor record keepers and as a consequence it requires constant surveillance to maintain suitable records of such material. This results too often in duplication of expense or operating with second rate parts and machinery due to not having a proper replacement part at the right time.

Briefly, this is the basic scheme around which the preventive maintenance program of the Warren District of Republic Steel Corp. was organized. Obviously, the successful operation of this, or any similar program, is a function of the knowledge, training, determination and most importantly the interest and cooperation of many people.

To help develop this atmosphere and to insure a proper concept of maintenance in future mechanical

W-3430—10M 7-51 2367③ REPUBLIC STEEL CORPORATION AND SUBSIDIARIES

DATE	ORDER NO.	AMOUNT ORDERED	RECEIVED	USED	BALANCE	DATE	ORDER NO.	AMOUNT ORDERED	RECEIVED	USED	BALANCE

NO. IN USE	WEIGHT	WHERE USED	LOCATION
DRAW NO.	DESCRIPTION		
PATTERN NO.	MATERIAL	PATTERN NO.	MATERIAL

Figure 5 — The departmental mechanical foreman is required to store and record on this form necessary replacement parts.

department supervisory personnel, indoctrination in and actual field experience with all phases of this work is made a part of our technical operating trainee program.

This program has definitely paid dividends. Many breakdowns of major proportion have been avoided and mechanical delays have been reduced to within practical limits. In spite of the good work done there is still too much lip service to the preventive maintenance philosophy. Practical application of its principle has great rewards for those who will work at it.

Remember, costly repairs often result from neglected maintenance.

Discussion

PRESENTED BY

W. ROESCH,
Assistant Superintendent of Maintenance,
Jones & Laughlin Steel Corp.,
Cleveland, Ohio

RICHARD F. ARMITAGE,
General Superintendent, Warren District,
Republic Steel Corp.,
Warren, Ohio

W. D. EVANS,
Cost Engineer, Construction Dept.,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

HUGH THOMAS,
Assistant Superintendent, Mechanical Dept.,
Bethlehem Steel Co.,
Sparrows Point, Md.

THOMAS NOLAN, Chief Engineer,
Atlas Steels Limited,
Welland, Ontario, Canada

W. Roesch: We certainly agree that the keystone of any successful preventive maintenance program is an adequate and systematic inspection procedure. In our mill, the assigned maintenance groups are primarily responsible for inspections, adjustments, and remove-and-replace type maintenance. This, of course, requires a very effective spares program, as Mr. Armitage stated. The benchwork or build-up of spare units and major repairs are a part of the shops' responsibility in the general maintenance group.

It is difficult to impress upon an inspector the importance of his duties and the keeping of records, but records are fundamental in rectifying the maintenance problems. This is a far cry from the old days of maintenance men waiting for the whistle to blow to go to work.

Mr. Armitage has mentioned the training in their preventive maintenance program, which has been made a part of the operating trainee program, and I would like to ask how and from what group the inspectors are chosen, and if any formal type of training is given to those selected. I am assuming now that the inspectors are hourly paid people.

Richard F. Armitage: We do not have any inspectors as such. As I stated, initially we used machinists to get started, but as we progressed with our program that function was transferred to the millwright foreman in each group. As of right now, the millwright foreman is the inspector.

As far as the training of these people, they accompany the millwright foreman on his inspections and also his follow-up of the things that he finds in his inspection, and, of course, they get a chance at trying the ultrasonic gage and other tools that are used by some of the personnel in the shop.

W. D. Evans: Is your maintenance organization one of central shops and departmental maintenance?

Richard F. Armitage: Yes.

W. D. Evans: How large is your maintenance group within the departmental area? By this I mean, is it a skeleton force for minor repairs and adjustments, or is it a full repair force capable of handling most breakdowns?

Richard F. Armitage: I would put it in the class of a full force, although at times we have supplemented it.

W. D. Evans: In other words, you would pull from your central shop group to supplement your departmental in case of breakdown?

Richard F. Armitage: Yes, we do that.

W. D. Evans: Are your departmental maintenance people assigned to an area, piece of equipment or do they cover an entire department? To us this is quite an important factor.

Richard F. Armitage: Basically, they are assigned to the entire department. We have a few places where it is on sort of an area basis, but the basic setup is for departmental coverage by the organization.

W. D. Evans: Specifically, you would not have an individual or a group of individuals whom you might term as motor room repairmen or motor room attendants, motor room repairmen who would stay right within that area?

Richard F. Armitage: No. The closest thing we come to on that would be in some of our work on bearings in the strip mills. We have people who pretty much of the time are spending their effort on the servicing of the roll setups for the mills, and that is not always a maintenance operation in terms of what you are doing; in other words, they are just removing bearing chucks from one roll and putting them on another to a large extent. Those people might be put in the class you mentioned. The rest of them are general.

W. D. Evans: After your program is established and a departmental mechanical foreman assumes the responsibility for the Preventive Maintenance Worksheet, how does he maintain this worksheet?

Richard F. Armitage: He is free to use his own judgment and initiative on that. There is nothing compelling him to do all this by himself, and we, in fact, encourage him to delegate as much as he can, providing he is still willing and ready to accept the responsibility for the results. In other words, we like to think that everybody—and I do not suppose we can say that this is the way it is—but we would like to work toward this goal, that everybody on the maintenance force is as interested as the foreman in doing a good job of preventive maintenance if for no other reason than to make their job easier.

W. D. Evans: In other words, the mechanical foreman could still depend upon his group leaders to convey to him, by means of notes, any inspection which he may have made in the course of the turn and thereupon listing what the difficulty is which he may have found?

Richard F. Armitage: He can and he does, in all cases I would say.

W. D. Evans: Further, I note that you advocate decentralization of spares; also that you recognize the tendency to hoard.

Other than having locker inspection once a week, have you a method of controlling the so-called hoarding?

Richard F. Armitage: We very definitely have. We have a district committee, it is known as a district inventory committee. It is divided into two principal categories: One is product inventory and the other is spares inventory. The subject at hand comes under the spares inventory.

As general superintendent of the plant, I have the responsibility of acting as chairman of the spares inventory group mostly because of my background in mechanical maintenance. We have tried to make, in the last six or eight months, inspections in our various departments not less than every two or three weeks. A part of that committee follows up after the basic inspection is made and the report is issued. Several people on the committee are, you might say, assigned as a subcommittee to go back out in a few weeks' time and see what has been done.

We also take pictures to make sure that some action is going to take place on recommendations that are made.

Hugh Thomas: In many respects it is similar to a program in effect at our Sparrows Point Plant. From experience we can say that if such a program is fitted to the needs of the particular unit and effectively administered by the maintenance supervisors, it will reduce delay time. However, as the author has pointed out, neither this program nor any other program will be effective unless the supervision responsible has the necessary patience, persistence and enthusiasm to carry out the program.

We also use the ultrasonic gage on hot metal car axles, rolls, shafting, pinions and, on the progress of the depth of a crack after a crack has been discovered. However, this tool is mostly used in our own shops. We found that in most instances, we can use the penetrant dye method in the field to greater advantage where it is more adaptable than the sonic tester, specifically when we have had a serious wreck in the mills resulting in broken spindles or couplings and so forth.

Figure 5 showed the inventory record card. This is a very effective tool for maintaining spares. We found it advantageous to include a spare part number on each card and a minimum and maximum number of spares for each item. With this as a guide, the spare part cards can be processed by nontechnical clerical help. Cards showing the number of spares under the minimum are passed onto the maintenance foreman for reordering. Effectively administered, this system can be very economical in keeping spares stocked at the lowest, yet safe level. We also found it advantageous to tag each spare part with the same number which is shown on the spare parts cards. This method has improved our record keeping and also the locating of some of the smaller spares, which are similar in size and design. Proper facilities to store parts must be provided in order to properly maintain suitable records on spares.

We wonder how you approach a very important bearing problem. At our Sparrows Point Plant, particularly in the hot and cold strip mills, our work roll and backup roll bearings have been a maintenance problem. One of the means we use to keep records is a card record system for individual work roll and backup bearings. The day-to-day information on the condition of and repairs made to the bearings is entered on the cards by clerical personnel who also color code the date with an index signal, and every three months a list of bearings which have not appeared on our record for their regular check is turned into the mechanical foreman for review.

We wonder whether you have such a problem on bearings. If you do, how do you process your records and take care of some of the repairs on your bearings?

Richard F. Armitage: We approach it somewhat similar to what you have described. However, I doubt if from what you have said we are doing as well as you are.

We have on our backup bearings a similar record to the one you described I am speaking now of the Warren District. I happen to know, however, in our Cleveland Plant they have gone in for that almost in identically the same manner you have described, and I think in the near future we are going to branch out and get into that a little bit more ourselves; but we do have a record, on backups only—not on work rolls.

We have more or less jobbing mills, I suppose you would say the same thing about your place, and there are a tremendous number of roll changes involved. It is almost impossible to keep up with the work roll bearings as you would with the backup bearings. That has been our feeling.

Thomas Nolan: I would like an elaboration on how work orders are processed. Is the work planned and scheduled?

When one has a shop force, the question is this: Is that really on day turn only, or do you have partial coverage from a central place for evening and night turn? I am thinking in over-all terms of your force to back up maybe your assigned people.

Richard F. Armitage: In our standard accounting procedure, we have what we call a job order system. That job order in any particular case is initiated by the foreman of the department, in this case the mechanical foreman. If it should happen to be electrical, of course, the electrical foreman initiates it. He has to provide with that job order sufficient copies of any blue prints or any information, e.g. sketches and the like. It is then submitted to the departmental superintendent for authorization.

It then goes to the shop area where it is processed by various people. Probably one of the first to take hold of it are the people who set up the incentives on the job.

Thomas Nolan: Do you have major coverage on all shifts for the shop force?

Richard F. Armitage: Now, as to the shop force on other than the day turn, we have coverage on the 3 : 00 to 11 : 00 pm turn, or third turn. However, except in the case of breakdowns, which we naturally try to keep at a minimum, these people seldom leave the shop. They are working on the parts that are necessary as described on their shop orders. However, they are available in the event of a breakdown and wherever it is necessary for them to go out.

Thomas Nolan: What happens on the evening and night turn regarding planned work?

Richard F. Armitage: As far as the off-turn work and how it is planned, we have what we call a general millwright foreman in every area. He leaves a list of the work for the afternoon and night turn to accomplish, and, of course, they indicate whether they have or have not accomplished it on that list so that he has a check on it when he returns the following day.

Thomas Nolan: How do you associate electrical and mechanical trades regarding work?

Richard F. Armitage: As to the association of the electrical and mechanical departments, in our case they are separate departments. Naturally, where you have a different responsible head and different administration and so on, it is a natural result to get in a dispute at times about who does what, especially when it comes to couplings and things like that; but generally speaking I think I can say that we enjoy a fine spirit of teamwork between the two forces, probably due mainly to the leaders, in this case the people that head up the organization.

Thomas Nolan: Do you have incentives?

Richard F. Armitage: We do have incentives.

Thomas Nolan: Whether or not to take major equipment out of service for maintenance is decided by whom?

Richard F. Armitage: Finally, getting major equipment out of service is a combined function, usually starting with one of our maintenance superintendents who consults with the operating superintendent as to how important it is to take it out, and their feelings in the matter are respected in most instances. There are cases where the people above them have to get involved to arbitrate differences of opinion, but that is not too often. ▲

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Maintenance work requires a more varied knowledge of welding than production work . . . . the maintenance man is confronted with repairing a wide variety of shapes and materials and this necessitates selecting the best method from the many available to best solve the metallurgical problems set up by the joining procedure . . . . costs cannot be overlooked either.

Maintenance Applications of Welding

by R. J. Osborn, Superintendent Maintenance,
Rolling Mills, Steel Div., Ford Motor Co., Dearborn, Mich.

THERE are fundamental differences between production welding and maintenance welding. Whether welding car bodies together or fabricating pressure vessels for an atomic reactor, production welding within a given situation is generally limited in scope. There is concentration of knowledge and supervision, specialization of technique, and control of conditions. This creates a completely different situation than that of maintenance welding. The bewildering assortment of work confronting the maintenance shop requires great versatility. There is just plainly a completely different situation between the two types of work.

Typical of the variety of work done by our shop often simultaneously, is the following:

1. Gas welding tips of hard facing material on bits for handling ingots.
2. Building-up worn surfaces on finished parts with all the problems of distortion.
3. Emergency repairs of parts where the analysis and condition of these parts is unsure.
4. Repairs to stainless steel burner tubes.
5. Thermit welding and hard-surfacing.

Now compound this situation by adding the presence

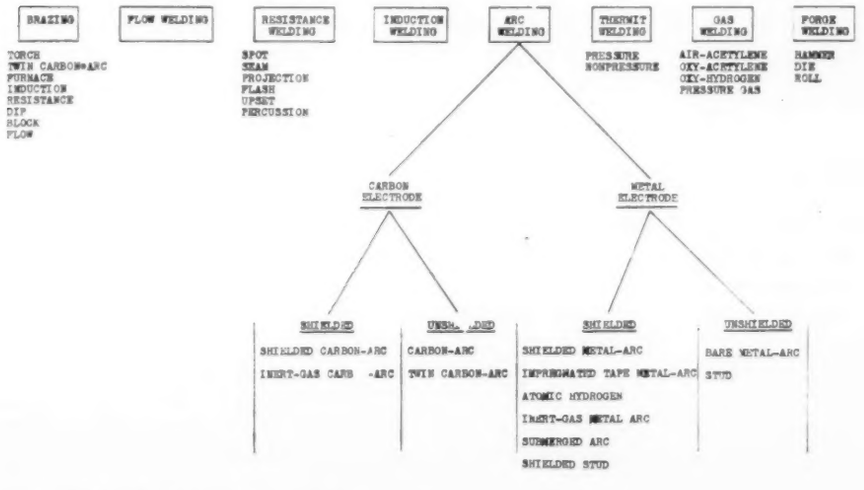


Figure 1 — American Welding Society master chart of welding processes.

Figure 2 — In the background is a completed spindle, and in the foreground are two ends to be welded.

Figure 3 — The two pieces shown in Figure 2 are assembled in the mold.

of welders working with assigned maintenance crews in the field as a part of a group of men representing four or five trades and supervised by a foreman who is the best man for his job, but whose knowledge of welding is apt to be rather elementary. To get the best work possible then from both the welding shop with its variety of work and from the field forces with their lack of specialized supervision is not an easy problem.

Good applications of pretty standard procedures have been made, that is, the most efficient utilization of each of our tools.

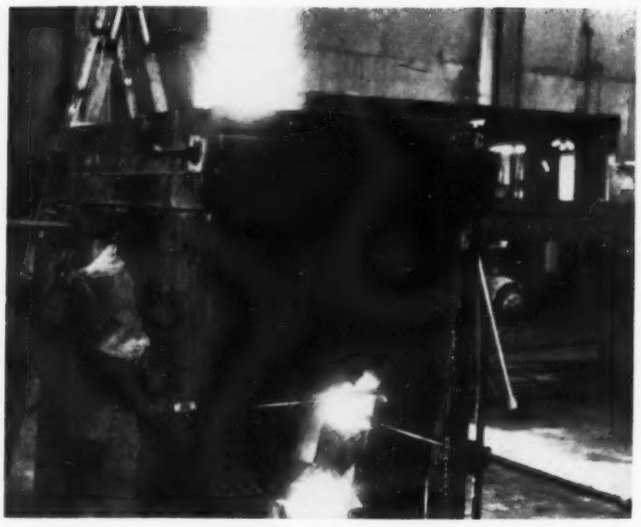


Figure 4 — The pieces to be welded are preheated to about 1800 F.

Figure 5 — The metal is still over 4000 F when tapped.

As background information, Figure 1 shows the master chart of welding processes as given by the American Welding Society. Our examples all fall into two major classes, thermit and arc welding.

Thermit welding has been used commercially since 1902. It is based on the simple fact that aluminum has a greater affinity for oxygen than does iron. Therefore, if a quantity of aluminum powder and iron oxide, such as mill scale are mixed together and sufficient heat applied to start the reaction; the oxygen runs from the iron oxide to the aluminum. The products of the reaction are aluminum oxide, iron and considerable heat. This is an over-simplification, of course, but the following example will illustrate.

In our last modernization program, the third roughing stand of the hot strip mill was relocated to the first-stand position. Because of interference with a building

Figure 6 — The mold has just been removed from the weld.

column, the combination drive had to be moved closer to the mill housings thereby requiring shorter driving spindles. The original set was purchased as a part of the program, but no spares were provided. In order to utilize the obsolete spindles rather than buy new ones for spares, a piece was cut out of the center of the old ones, and the ends were welded together.

Figure 2 shows a spindle in the background. In the foreground are the two ends to be welded. The small dowel in the center holds the ends in line and yet apart to leave a gap into which the molten metal can flow.

Figure 3 shows the two pieces as they are assembled in the mold. Wax is used to provide a cavity in the mold, and sand is shovelled in and tamped, much like a mold in a foundry. The steel plate ends are, of course, added as the ramming continues. The mold is built up to cover the part, holes being left for gate and risers.

The arrangement, Figure 4, is now heated to about 1800 F to melt the wax and preheat the pieces to be welded. When the preheating is complete; the crucible, filled with the thermit mixture, is mounted above the mold and the reaction started.

Temperatures approaching 5000 F are reached in this process. After the fireworks have died down, the stopper is raised allowing the molten metal to flow into the mold. The metal is still over 4000 F when tapped as shown in Figure 5. Although fundamentally a casting, the weld metal approaches a forging in strength. This is probably due to the fluidity of the weld metal at this temperature permitting impurities to rise very easily. Solidification occurs from the relatively cold parts outwards which also aids in forming a sound and dense structure.

The mold has now been removed from the weld, and the part is now ready for finishing as shown in Figure 6. Completely machined, these spindles cost just over $1000 each as opposed to $8500 for a new one. A pair of spares made this way saved more than $14,000.

The driving spindles on the finishing stands of the same mill are similar but slightly smaller. These spindles are designed to break to prevent damage to the drive or motor when a wreck in the mill occurs.

Figure 7 shows a typical failure with one jaw torn off. The bad ends of two broken spindles were cut off

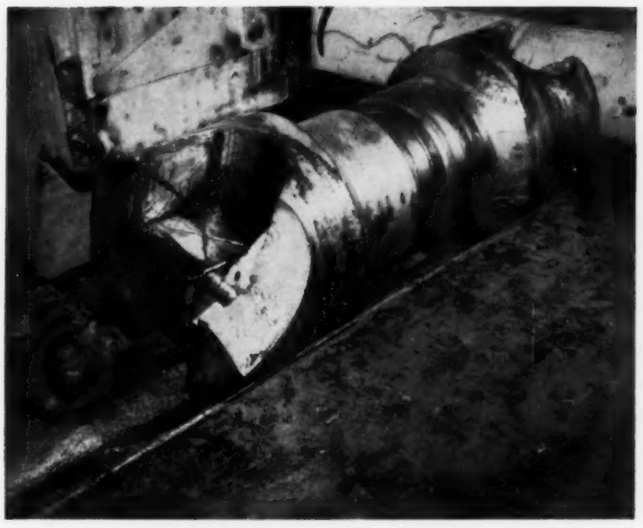


Figure 7 — Typical failure of a drive spindle.

Figure 8 — A spindle is shown here after welding with the riser burned off.

and made good with a thermit weld like that of the previous job.

A spindle is shown in Figure 8 after welding with the riser burned off. It is now ready for machining. The total cost of weld and finishing is under $1000 compared to as much as $2500 for a new part.

Our blooming mill required two jobs. The first concerned the driving spindles and the second, the side-guard arms. Some years ago two of these spindles were broken much as the one on the hot strip mill. The spindle head was turned down and a new end shrunk and keyed on. In 1956 the jaw of this repaired spindle was broken. Plans were to press off the head and shrink on a new one. A number of small cracks was found on the shaft proper adjacent to the head. Our ideas changed accordingly.

Figure 9 — The completed weld of an old spindle and a new end.

Figure 10 — Closeup of a broken blooming mill manipulator arm.

Figure 11 — The weld has been made and is cooling in the mold.

Figure 12 — This is the completed weld before machining.

Figure 13 — An 84-in. reversing cold mill reel had a break located at an undercut next to the large center bearing.

The old spindle was cut off farther back, and a new end was purchased. Inasmuch as we have no lathe large enough to handle this spindle, the head was ordered completely finished. The mill builder, who furnished the new end, wrote to make sure we did not want stock left on the piece. There is, obviously the hazard of distortion in making such a weld.

Figure 9 shows the completed weld. Of course, no attempt was made to remove the collar. The completed 18-ton spindle is 26 ft long. It was put into service in June and has run without incident. This was surely a cheap way to get a good-as-new spindle.

Two of the arms of the blooming mill were broken as shown in Figure 10.

The arm was cut off a considerable distance back from the break, and a new forging was welded on. This was done for two reasons. There was room in the mill to take an arm ½-in. thicker, and at the same time the weld could be moved away from the critical zone around the bend in the arm.

In Figure 11 the weld has been made and is cooling in the mold. These arms run from 23 to 27 ft long and cost more than $6000. The repairs vary from $1200 (for welding right at the break) to just under $3000 for those using a new forged end.

The completed weld before machining is shown in

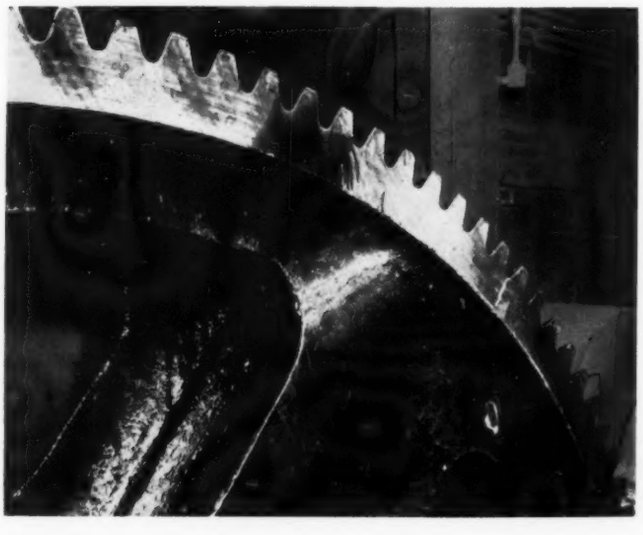
Figure 12. The little tail on the left is the hole in the mold for the preheating torch.

Two identical reels on our 84-in. reversing cold mill were the severest test of all the welds our shop made. The two reels were installed in December, 1953. On February 23, 1955 the north reel shaft was broken, and our spare was installed. The break was located at an undercut next to the large center bearing. There was a sharp corner in this undercut which undoubtedly started a fatigue failure. The closeup of the failure, Figure 13, confirms this. The other reel on this mill and a third identical shaft on the skin pass mill probably had the same sharp corner and might already be cracking. Although another one was ordered immediately, it would take several months to receive it.

Even though there was not too much choice in the matter, it was felt there were too many problems to get a good weld. Some of these difficulties were imposing ones. The large temperature changes during welding often cause distortion. This distortion would be magnified by the length, over 20 ft, of this shaft yet the reel certainly must run true. Further, the weld had to be made in the heavily loaded section where it broke. The classical repair would be to cut off one piece or the other back to where the shaft was larger, or the stresses less, and then weld to it a new forging with sufficient stock to permit finishing after welding. Here the break was almost exactly in the center; and to get such a forging, make the weld, and machine it would have taken practically as much time as the new one. The shaft was hardened alloy steel to make matters worse. With all possible precautions the broken halves were welded together. The weld was tested for soundness and drillings analyzed for composition. All tests indicated success. Machining and re-assembly completed the job. The other reel did break in December of that year, and the welded reel was installed. After 18-months service it was removed after a wreck occurred which threw a terrific overload on the shaft. Although one of the parts of the assembly was literally torn off the reel, the weld was undamaged. It should also be noted that the new shaft cost $8000 and the repair less than $2000.

In arc welding, the electrode is touched to the work, and the arc jumping from one to the other liberates

Figure 14 — Shown is a weld made on the spoke of a gear in the drive of a hot strip mill finishing stand.



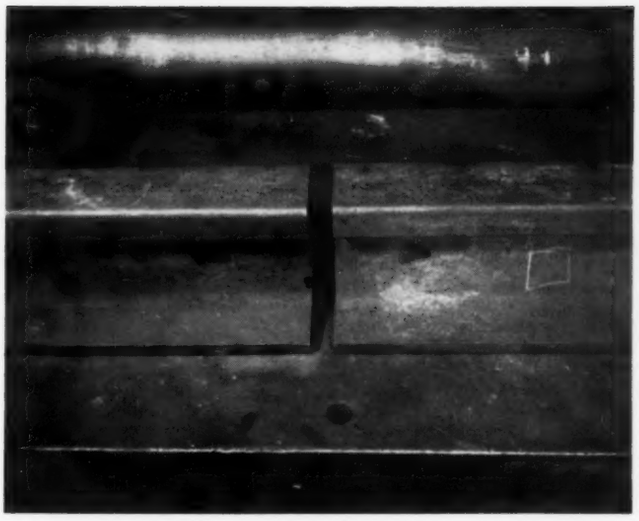


Figure 15 — To correct a bad crane rail joint a gap is made between the two ends by burning and grinding to accommodate the weld.

sufficient heat to melt a little puddle in the work piece. If a metallic electrode is used, substantial quantities of the electrode also flow into this puddle. When the puddle is at the junction of two pieces, its solidification leaves them fused or welded together.

In this fusion welding, there are three important metallurgical phenomena. First, the puddle of metal solidifies much like a chilled casting. Second, parent metal adjacent to the weld is heat treated with conditions varying from almost-melted near the weld to barely warmed farther away. Third, the obvious push and pull of expansion and contraction are caused by the temperature changes.

Some understanding of these three phenomena are the most important knowledge anyone dealing with welding can have. The typical welder is an eager, optimistic fellow who will, at the "drop of a hat," start welding anything convinced in his own mind that welding is the answer. This can be disastrous. It is the supervisor's job to be sufficiently aware of the problems involved to make an intelligent decision as to if and how a weld shall be made.

Such a decision had to be made in 1953 when a crack was discovered in a spoke of a gear in the drive for the second finishing stand of our hot strip mill. Early in 1957, more than three years later, a second crack developed, and it was decided to weld the cracks. The gear was first warmed as much as possible. The cracks were widened at the surface to get maximum penetration and then welded and peened. Peening is done, of course, to compact the metal and to compensate for the cooling shrinkage by spreading the weld laterally.

Figure 14 shows the completed repair. The gear had run from last April to the present, January, 1958, without additional failure. There is a definite hazard in this type of welding. The intense local heat present when widening the crack with an oxyacetylene torch, and again when welding, causes corresponding local expansion that acts just like a wedge and may drive the crack even deeper.

A bad crane rail joint developed in the annealing aisle and introduced a very obvious problem, the selection of the proper electrode. For some time the proper

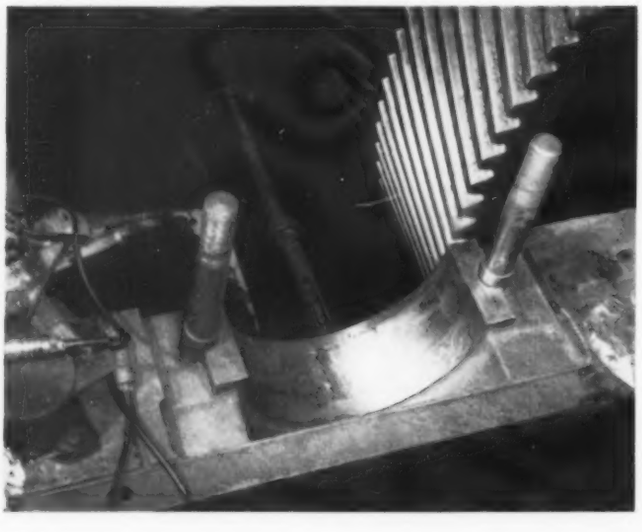
technique and rod to weld joints was sought. The bolted joint with its accompanying gap becomes pounded out long before the rail is worn out. These bad joints cause wheel spalling and shake the crane severely. The pounding on the rail itself also causes cracks to develop.

Concurrently a problem in premature rail wear along with bad joints developed in the very busy aisle that unloads the conveyor from the hot strip mill and loads those feeding the pickle lines. It was decided to try a specially heat-treated rail. Another procedure and rod for welding joints was introduced by the rail supplier.

Figure 16 — The gap has been filled with weld and the top ground flush.

Figure 17 — This section of a blast furnace bell was welded with a stainless steel wire.

Figure 18 — Years of service had resulted in depressions in the bearing's seat by its rollers. The seat was welded and then ground back to its original size.



The preparatory work recommended for this method was extensive—first burning and then grinding. The suggested rod and our own methods were combined. A gap is simply left between the ends of the rail, Figure 15, and the void filled up.

Although it is obvious that working from the bottom up through a long gap is not easy and care has to be taken to clean the slag after each pass, it works.

The weld is ground flush on the ball of the rail, Figure 16, and finally is postheated and covered with asbestos board for slow cooling.

One joint has been in heavy service since September, 1956. There are now several aisles with extensive lengths of welded rails, and in going from an aisle with bolted joints to one with welded joints, the difference in the sound and feel of the crane is amazing. Even though some slight wear is present at the joint, there is not the least jar as the crane passes over. When the proper selection of electrode can change failure to outstanding success, the importance of this selection is obvious. Here again the problem of maintenance work with its varied nature is underlined. Of the hundreds of fine rods available, which is the best for each one of the many jobs facing the maintenance supervisor?

An eroded area on a blast furnace bell was welded

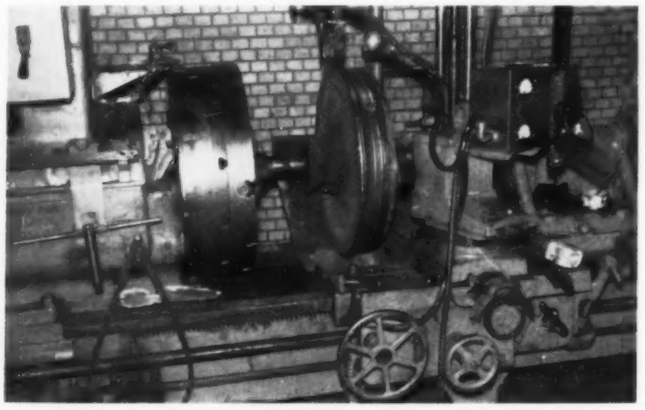


Figure 19 — A wheel is being welded on this old lathe converted into an automatic welder.

Figure 20 — The welded wheel is smooth and easily machined.

Figure 21 — Submerged-arc welding is smoother and more even than hand welding.

with No. 308 stainless steel wire—no kin at all to the parent material. The section is shown in Figure 17 after 650,000 tons of iron had been produced in the furnace.

The hot strip mill gear housings were installed in 1935. All the large ones were made of cast iron. Roller bearings running in these housings pound depressions into the iron. The most desirable way to repair them is to bore out the seats and install steel sleeves. This requires a lot of time and money.

These seats are welded with a nickel rod and then ground back to the original size. An undamaged area is left on each side of the weld for reference, Figure 18, and the outer race of the bearing is blued in to get proper support.

The arc-welding jobs illustrated have all been done by hand. If considerable work in a repetitive pattern is to be done, an automatic welding machine can be used. An old lathe can be converted to utilize the submerged arc process. A wheel from the high line transfer car is being welded in Figure 19.

There was quite a bit of wear on this wheel to be replaced. To hand weld this wheel would have been most uneconomical. The welded wheel, Figure 20, is smooth and easily machined. All sizes of crane wheels are regularly built up this way. Although the final product is inferior to new wheels, the cost of this repair is so low the work is more than justified.

Rolls are regularly built up for almost every place in the mill. These range from blooming mill table rolls where 1½ in. wear is common to coiler rolls and leveller rolls where ⅛-in. wear is maximum. A feed roll for the blooming mill was built up of a mild-steel, hard-face combination. A new roll costs $3400. The cost of repairs will run up to $900 depending on the amount of wear. Two blocking rolls for the hot strip coilers were originally alloy cast iron. They wear hour-glass shaped and then have to be ground. An average of four months per grind was had on the iron rolls. As much as a year on the built-up rolls has been obtained.

One of the most successful applications has been on leveller rolls for the cold mill. The original rolls were carburized and hardened steel rolls. They cost from $1000 to $1500 each. The repaired rolls cost from $300 to $600 each. The interesting point is that the built-up rolls are much softer than the new ones and yet actually run longer, saving money both ways.

Submerged arc welding, Figure 21, has several advantages over hand welding. It is faster both in rate of deposition with fewer inherent delays, changing wire, human needs, etc. It gives a much more even smoother deposit. Table rolls are neither machined nor ground. If they were hand welded, this would be impossible.

When a cast iron crane drum broke, there was no spare. The piece was brazed—not welded right back into place. The drum ran until a new one was received and was still usable when removed from the crane.

Our slab shear blades were always edged with hard-facing material. Two years ago these blades cost $1100 each. Some solid steel blades at about $500 each were tried, and surprisingly they run longer than the expensive edged blade.

In summary, welding is only one of many ways to do a job. The selection of the best way—all factors considered—is the measure of how well we do our job.

Discussion

PRESENTED BY

A. CHAPMAN, Manager of Maintenance, Plant Engineering Dept., Central Staff, Ford Motor Co., Dearborn, Mich.

R. J. OSBORN, Superintendent, Rolling Mill Maintenance, Steel Div., Ford Motor Co., Dearborn, Mich.

ARTHUR HOLM, Foreman, Miscellaneous Shops, Maintenance Dept., Steel Div., Ford Motor Co., Rouge Plant, Dearborn, Mich.

WILLIAM D. MACDONNELL, President, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

STEPHEN T. KRAFT, Superintendent, Strip Mill Maintenance, Steel Div., Ford Motor Co., Dearborn, Mich.

KENNETH T. BRADY, Superintendent, Mechanical Maintenance, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

WARREN E. HART, Superintendent, Electric Furnace Building, Ford Motor Co., River Rouge, Dearborn, Mich.

ROBERT PERRY, Industrial Heating Specialist, Westinghouse Electric Corp., Detroit, Mich.

A. DONALD SHATTUCK, Superintendent, Coke Oven Plant, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

JOHN HERTZA, Superintendent of Maintenance, Steel Div., Ford Motor Co., Dearborn, Mich.

E. H. BUBLITZ, Manager Repair Specialist, General Electric Co., Detroit, Mich.

FRANK L. BRUNNER, Manager, Service & Maintenance, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

DONALD E. BIRD, General Foreman, Electrical Maintenance, Steel Div., Ford Motor Co., Dearborn, Mich.

W. E. MILLER, Manager, Metal Rolling & Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

JAMES WILSON, Consulting Engineer, Thermex Metallurgical, Pittsburgh, Pa.

A. Chapman: Do you do any metallizing to repair or build up any parts over the mill?

R. J. Osborn: No we do not as yet. Right at this moment there is a purchase order outstanding with an outside company where we are going to attempt to repair the inside of one of our mill housings. We want to try and build the surface up with metallizing. As yet we have not done this. It is pending.

A. Chapman: What is the specification of the metallizing material?

Arthur Holm: Our first preparation will be roughing and cleaning, of course, bonding material below, and it has not been decided whether we are going to use a stainless type over and above the bonding or whether we will use a low type of carbon alloy.

William D. MacDonnell: What sort of a preventive program do you have at Ford Motor in determining when to replace various equipment parts? Do you do any magnafluxing to make this determination? What other means do you have at your disposal?

Stephen T. Kraft: We have bought magnafluxing equipment and the so-called ultrasonic equipment. I would say that all heavy shafting, and material similar to that which you saw on the manipulator arms shown in Figure 10 are systematically checked. Every place it is possible for us to make a thorough and complete test, either one or the other piece of equipment is used to check.

All thermit welds, wherever it is possible, are tested with the ultrasonic equipment. We feel that this equipment is not infallible, but we feel that it does supply, (from the tests that we have made on straight shafting and fairly regular parts), a very accurate answer as to whether the welding or repair work has been satisfactory.

We do have the equipment, and we are pleased with it, and to tell you the truth, we are hoping to enlarge and expand on it.

William D. MacDonnell: I am glad to hear that because we just purchased some new equipment for magnafluxing and testing our own equipment at the mill.

I was also particularly interested in your work on crane runway rails. One thing I am curious to know is what you did there. Is that just on repair work, or have you made it a practice of welding all rail joints on replacements throughout all your plant?

R. J. Osborn: It is something we do when we install new rails rather than running around after every rail joint that is broken down a little bit. In other words, it actually has been done by us more significantly in installing new rails where the old ones were worn, where we would put in 700 or 800 ft of rail in a single aisle with no welded joints in them. We have not installed any new rail where we have not welded new joints.

William D. MacDonnell: Have you tried any thermit welding of these weld joints?

R. J. Osborn: Mr. Holm did that experimentally in the shop some time ago. There is no question in my mind at least that this method is more than successful, but you have to take a crucible of some size or other up on the crane to make your weld.

Kenneth T. Brady: Have you ever tried arc welding with a submerged arc, joining the journals of a pinion, and if you have, what is your result?

R. J. Osborn: Do you mean a mill drive pinion, something like that?

Kenneth T. Brady: Similar to those couplings shown to be repaired by thermit welding.

R. J. Osborn: You mean thermit welding or arc welding?

Kenneth T. Brady: No, the submerged arc process.

R. J. Osborn: Where one is snapped off trying to put something on there?

Kenneth T. Brady: Either that or repairing same.

R. J. Osborn: On mill pinions our practice has been, and we have done many of them, to bore out the inside of the mill pinion and then press in a plug of alloy steel. That has been our practice. We were fortunate in that the fixed diameter of the pinions is large enough to permit a sizable plug to be shrunk in there. So that has been our repair. To my knowledge we have broken one in the mill that has been so repaired.

Warren E. Hart: Since we have many bronzes and coppers around the plant, I wonder if you ever explored that more fully as to brazing or welding copper outfits rather than purchasing new ones.

R. J. Osborn: I do not have anything to do with the parts in the blast furnace.

Warren E. Hart: I wonder why they do not weld the water cool-off around the blast furnace when they have a leak, or the bus-bars on an electric furnace, or the water clamps on the furnace.

R. J. Osborn: Be careful when you get into conductivity because bus-bars are pure electrical outlets. If you were to try and weld copper, you would have problems. Bronze is weldable. There is an aluminum bronze regularly made in arc welding—maybe there are other bronze analyses—but you could not use that bronze for electrical conductivity. It would be 50 per cent conductive probably.

As far as repairing bronze castings by welding, I cannot speak for the blast furnace. I do not know.

Stephen T. Kraft: Actually, we have that answer on chills and coolers, and I am thinking about blast furnace coolers. Frankly, they do not present a problem, a serious problem that is, from the standpoint of being able to weld them. Those chills as castings do require special care, some degree of preparation, are weldable and test under pressure very satisfactorily.

This other problem about conductors and bus-bars, I do want to support Mr. Osborn's statement that you must be careful in the area where conductivity is a very important factor. I am not saying that such a thing is impossible, Mr. Hart. I am just saying that so much care has to be taken, and the risk is so great that some of us have not dared tread that path as freely as we have trod other paths.

Robert Perry: Two examples were given of where a softer material outwore a harder material. Has anyone given a satisfactory explanation for this?

R. J. Osborn: I think it has to do with the nature of the abrasive condition. There are certain properties in certain materials called lubricity and toughness for lack of better names. Why does mild steel pick up when used in conjunction with mild steel, and yet mild steel on an extremely hard steel will wear very smooth. I think there is a surface effect that develops toughness.

A. Donald Shattuck: What approximate labor time would be necessary, in your opinion, in the welding of two heavy-duty 170-lb rail sections?

R. J. Osborn: That is getting heavy. I can speak readily about 80 or 100 lb. One welder with maybe a couple of men will make two welds easily in a day.

John Hertza: If I remember correctly, Great Lakes was putting on a program of preventive maintenance. They were in the process, and I would like to know how it has progressed, if any.

E. H. Bublitz: It seems to be an age-old problem in maintenance that at peak production periods it is next to impossible if not impossible to get a piece of equipment, be it mechanical or electrical, down for repairs, although immediate repairs are indicated. In your productive maintenance program, and as we have previously stated, we favor that term, has there been any indication of forward thinking among the gentlemen who control the budget strings of accruing for such repairs, to be performed at a time such as our present recession period, when production could be disturbed with a minimum of downtime penalty—or do you face the problem of when you are producing you do not have the time for repairs and when you are not producing you do not have the money? I would like to know if and how this problem is met in your present productive maintenance program.

Frank L. Brunner: We have a preventive maintenance program at Great Lakes Steel. We also refer to it as productive maintenance. It cuts down delays and therefore makes the mill possible to produce more. We have a particular area in which we have concentrated, but are still far from where we hope to arrive.

In this area we have eliminated all whistle stops. The millwrights, pipe fitters and electricians in the area now receive their assignment from a central shop. All work requests are made by phone or written order.

This requires the work to be projected in detail each day for the succeeding day. Proper lubrication schedules must be set up with proper inspection programs in order to project a maintenance repair before a breakdown occurs.

At the present time we have increased the performance of the workmen approximately 20 per cent.

Productive maintenance requires full cooperation between the maintenance people, the operating people and top management. We at Great Lakes Steel enjoy this relationship. Mr. William D. MacDonnell is one of the first to recognize the need of proper maintenance and the need of planning ahead. We are informed of anticipated mill schedules weeks in advance in order to project the maintenance accordingly. Our production managers and superintendents are the key to the success of this type of program, they project their production schedules with the maintenance people so that proper preventive maintenance can be included.

What do we do when money is tight? That is the age-old question. However, budgets are set up correspondingly with whatever the projected rate of operations is expected to be.

However, it still becomes a selling job for the maintenance people to point out to management the necessity of making certain expenditures in order to be able to keep their mill producing without costly delays and receive a favorable return on their investment.

When you have a centralized area assignment it does not necessarily mean that the production man does not have a workman he can turn to for emergencies. Workmen are making routine inspections on all turns, they are working in the spares area and on repair work assigned at the start of the turn.

But the thing that we have gained is the flexibility of using the workman wherever he is needed. We do not assign workmen to areas. However, when the job assignments are made, the foreman can at any time move any or all of the workmen to a breakdown in any area.

Donald E. Bird: Mr. Brunner, I believe, actually started on this productive maintenance and talked about eliminating the whistle stops out of the mill.

Actually out on the mill I imagine you have a short-wave system, in the mill you have a centralized shop. Now if an overload kicks out or an overspeed relay kicks out, you wait for that message. I do not believe I could over at Ford. Maybe you can explain that program more thoroughly.

W. E. Miller: We in designing our products and systems have been stressing the importance in not only just designing the product, such as a motor or complex automation control, but trying to recognize the ambient operating conditions to be encountered. This includes designing for process performance, for reliability as required by today's production requirements, designing for today's construction practices and designing for productive maintenance. Actually, the concepts of designing for reliability and for productive maintenance go hand-in-hand. The concept of reliability implies first that operation should be as trouble free as possible. Second, if trouble occurs, it should be easy to locate and repair.

Productive maintenance implies planning. This planning can start with product or system design by making it easy to systemize procedures to locate and repair trouble if it does occur. For example, in the area of automation control we have been providing:

1. Built-in automatic circuit checking.
2. Unitized construction.
3. Use of basic modules.
4. Training of user's personnel.

As we advance to systems of higher levels of automation, productive maintenance programs and products and systems designed to facilitate productive maintenance programs become much more necessary.

James Wilson: Thermit, as we call it, was brought over to this country in the early nineteen hundreds, about 1902 or 1903 perhaps, by the Goldschmidts, and it was developed further here. It was used very little, originally except on locomotive frames. That was one of its big uses when we had the old type locomotive frame.

Later on it went into the street railway field, for welding girder rail joints. In later years, we went to the crane rails and railroad rails.

During World War I it was started extensively in the steel mills. As you know, arc welding had not been developed at that time as it is today. Consequently we were called upon to make many repairs that the steel mills would not think of thermit welding today, but we had to do it then.

During World War II thermit had a great deal to do with the obtaining and producing our large number of ships in record time. Stern frames were produced by thermit welding heavy castings at the shipyard site.

There were only a few foundries in this country that could make a complete cast. By thermit welding they were able to assign a lot of that work to smaller foundries, ship to the yards and assemble and weld at the stern location where limited crane capacity could handle the load.

William D. MacDonnell: Is there any general guide that can be used to decide when you should use thermit and when you should use arc welding? The reason I am raising this question, last May we broke the main housing on our 40-in. blooming mill and we were rather in a quandary as to which way we should go for repair. But as a general guide, which way do you go? What do you use to decide whether it should be thermit or arc welding?

James Wilson: I do not think there is any guide for that. I think arc welding if properly done can weld almost anything thermit can weld, but there is one important factor, it depends much more on the man's skill and sometimes the time lag. After years of research we now recommend heat treatment after thermit welding and we can thereby produce any desired physicals.

We have elaborated on thermit for welding. It is not always used for that. There are other things it can be used for. In one particular case it was used by a leading steel corporation to light a blast furnace.

William D. MacDonnell: I would like to say that there was a time factor that decided us on the arc welding on this particular case.

Inspecting the feed roll in the housing, we found these cracks. Something had to be done. If we were going to thermit weld, we had to take stands out, lay it down. We decided to go to arc welding, and the men did a very fine job of it. We preheated to 400 F, started out and welded between each one.

We had our quality control people there to watch the temperature very closely at the bottom of the stand to check expansion. We had about 980 lb of weld, about two and a half tons of charcoal. We did it that way in about seven days, with about 110 hours of overtime. ▲

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CYCLIC WELDING METHOD Salvages Heavy Mill Equipment

by R. L. Rectenwald,
President
Maintenance Engineering Corp.,
Pittsburgh, Pa.

. . . . the cyclic weld method is unlimited as to mass of weld metal deposit, thickness of joined members and alloy composition of the parent metal . . . .

FROM the beginning of the machine age, industry has been frustrated in its many attempts to produce sound, economical and efficient repairs to fractured sections of massive machine frames and driving elements. Throughout the heavy metal working industry this frustration is manifest by an assortment of steel patches, welded enclosures, tie rods, wire rope, patch on patch of weld metal and even concrete encasements. Often these temporary repairs extend the productive life of the equipment but usually with additional maintenance cost and curtailed production capacity.

In seeking the solution to the problem of rejoining these massive fractured sections, the first approach was to recast the fractured area by removing the defective section and pouring molten metal in the fractured gap following foundry practice closely related to that used in casting the original parts. This procedure entailed a great loss of production time due to complete dismantling, shipping, positioning and remachining. Many compromises and adjustments had to be made in alinement and assembly. The metallurgical effect of pouring molten metal against the colder sections left much to be desired as regards proper fusion and soundness of the foundry weld.

The next development provided a means of accomplishing the foundry weld on location by providing a convenient portable cupola or crucible wherein the metal was melted by a chemical reaction. In 1897 the original patent was issued covering a chemical process producing an exothermic reaction between aluminum powder and certain metallic oxides. This process became known as the thermit method of commercial welding soon after the turn of the century. The thermit process found many applications throughout the heavy metal working industry, in shipyards, and on railways. However, the basic method and weld characteristics did not change materially until the process was discontinued by the parent company in 1958. The use of the thermit method is yielding to more modern methods in the industries which supported its early development.

While the thermit cast welding procedure provided a compromise over foundry welds in joining massive steel and iron sections, the physical properties and quality of the repairs were deficient by comparison with physical properties of the parent metal used in the construction of modern metal working equipment. Aside from the lack of strength and ductility, other problems common in foundry practice were even more pronounced when working under adverse field conditions. The deficiencies in thermit welding, where improvement was needed, were the following: internal cracking, hot tears, porosity, piping, sand and slag inclusions, hot metal handling hazards, extremely low ductility, poor impact resistance, low strength, coarse grain structure and poor machinability.

Recognizing the increasing need for a welding method which would produce sound joints in massive machinery sections of high physical properties, an arc welding procedure which eliminated practically all of the hazards and limitations of the old thermit cast welding technique was developed. The new welding technique is called "cyclic" welding because of the repetitive steps of welding and temperature stress relieving.

DEVELOPMENT OF CYCLIC TECHNIQUE

Some of the obvious obstacles to be overcome in the successful development of a suitable welding technique for welding of very thick sections in modern alloys were as follows:

1. To avoid conditions contributing to stress crack-

ing due to thermal expansion and contraction in massive rigidly restrained steel sections.

2. To avoid cracking caused by transformation of weld deposit and heat affected parent metal due to the untempered martensite phase during the welding operation.
3. To avoid age hardening phenomenon at welding and stress relieving temperatures.
4. To avoid cracking due to hydrogen embrittlement caused by dissolved hydrogen in the weld metal deposit.
5. To avoid the phenomenon of underbead cracking caused by a combination of adverse conditions in the welding of medium alloy and high carbon steels.
6. To assure against slag inclusions, laps and poor fusion attributable to the welding operator.
7. To avoid application of heat on complex shapes until the thermal conditions assimilating "free end" movement is provided.
8. Not the least discouragement is that many of the alloys and conditions are classified by some authorities as "not weldable."

Since most of the common ferrous alloys used in heavy machine castings and forgings are classified under the category of hypoeutectoid steels (those plain carbon and alloy steels having a carbon content of 0.80 per cent and under), this discussion will be limited to those alloys. It is not intended to imply that the hypereutectoid and high alloys cannot be successfully welded but the special high alloys and tool steels deserve some special treatment which will not be covered in this paper.

ISOTHERMAL TRANSFORMATION

Much of the background information provided for an appreciation of the metallurgy of welding is available in the extensive research publications over the past 10 years by E. C. Bain and E. S. Davenport of the United States Steel Corp.'s Fundamental Research Center. These investigations led to publication of isothermal transformation diagrams of practically all ferrous alloys manufactured today. The information gleaned from the isothermal transformation (I-T) diagrams provides us with effects of cooling rates on the microstructure of all plain carbon and alloy steels from the upper critical temperature to atmospheric temperature. These diagrams are plotted with temperature as the ordinate on a uniform scale, and time an extended logarithmic scale as the abscissa. A typical I-T diagram for a mild steel of 0.08 carbon steel, Figure 1, shows effect of cooling rate on a nonhardening steel. Figure 2 illustrates the behavior of an intermediate hardening steel of 0.50 carbon. The susceptibility to hardening at slower cooling rates is shown in Figure 3 which represents the I-T conditions for a deep hardening SAE 4340 steel.

Attention is called to the horizontal line marked M_s on the diagram which shows the temperature at which austenite begins to transform to martensite. M_{50} and M_{90} designate the temperatures at which transformation is either 50 per cent complete or 90 per cent complete in this order. It should be emphasized that the transformation to martensite can only proceed from the aus-

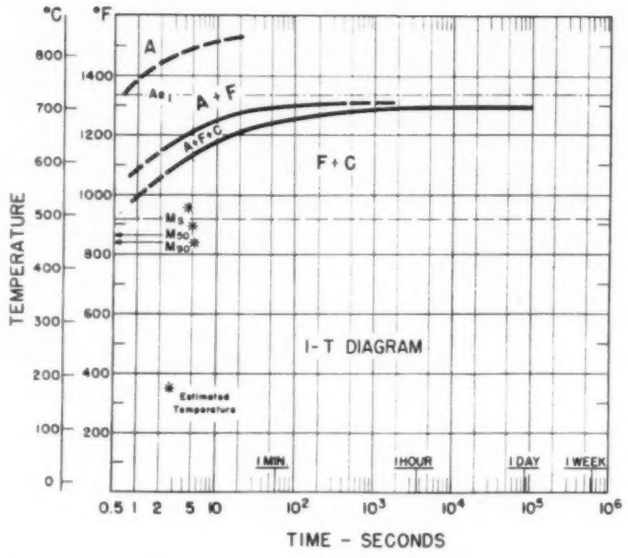


Figure 1—Isothermal transformation (I-T) curve for AISI-1008 steel illustrates behavior of nonhardening steel.

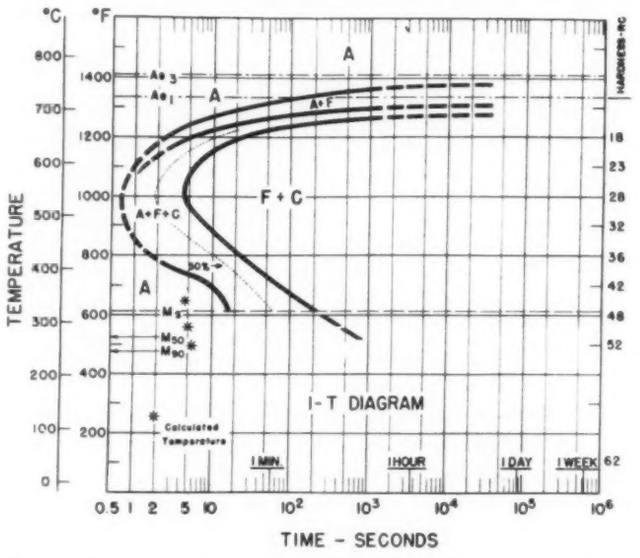
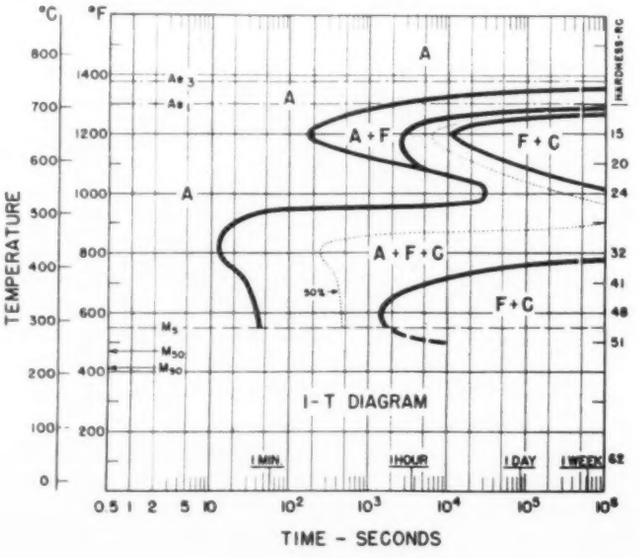


Figure 2 — I-T curve for SAE 1050 steel shows medium hardening behavior at slower cooling rates.

Figure 3 — I-T curve for SAE 4340 steel shows slow transformation time for deep hardening steel.



tenite (A) constituent and not from ferrite (F) or carbide (C) but to some degree from combinations of these phases as transformation approaches bainite. Therefore, in order to form 100 per cent martensite in the SAE 1050 steel, Figure 2, the austenite (A) phase must be cooled from above the upper critical A_{c3} temperature in less than 10 seconds to a temperature below M_s of about 600 F. A slower cooling rate of an hour or more would cause the transformation to proceed to the ferrite plus carbide (F + C) area and avoid formation of martensite below the M_s temperature. If by chance the ideal cooling rates were not attained and some martensite was formed, the steel could be reheated to a temperature just below the lower critical A_{c1} to accomplish complete relief of residual thermal stresses and tempering of the martensite.

Reference to Figure 1 for the AISI 1008 steel indicates that the dotted (calculated) portion of the 100 per cent transformation curve would cross the M_s line at about zero time showing that martensite could hardly be formed if the quenching time was instantaneous. Similar comparison to Figure 3 for the SAE 4340 curve shows that martensite would form upon cooling from A, to below M_s (550 F) at any rate up to about one hr.

Above the A_1 lower critical temperature austenite is in a solid solution stable phase. As temperature decreases below A_1 (approximately 1350 F for SAE 1050) transformation begins by precipitation of carbides, and a series of different microstructures are formed which possess a wide variety of physical properties. These microstructures are listed in Table I with approximate transformation temperatures and physical properties of a typical SAE 1050 steel which are significant in the welding process.

The preceding portion of the paper describes the manner in which the microstructures of the weld deposit and heat effected areas of parent metal vary with temperature changes encountered during welding. We can see that the isothermal transformation diagrams can be used as a guide in selecting preheat temperatures, cooling rates and welding temperatures to produce the most desirable microstructures and physical properties during and following welding. Of course, to control these conditions ideally, we must know the exact chemical composition, grain size and previous heat treatment of each piece to be welded.

In studying the complete scope of the variables within the range of hypoeutectic steels of less than 0.80 per cent carbon, it is possible to superimpose the various transformation diagrams into one diagram which provides all of the information needed for welding a wide range of common alloy steels. This diagram is similar to the continuous cooling transformation diagram and it shall be called an "isothermal welding diagram" for lack of a better name, Figure 4. The approximate preheat curve and weld deposit cooling curve has been plotted on the diagram to illustrate the patented welding procedure named the "cyclic welding method." In developing the welding diagram, the lowest preheat temperature has been set 50 to 100 F above the highest M_s temperature for the group of alloys. By retarding the weld deposit cooling rate past the nose of the transformation curves (1400 to 1000 F) to a minute or slower, the transformation of austenite

TABLE I

Transformation range	Austenite transforms to these microstructures	Physical properties
1400 F to A_2 (1500 F)	Stable austenite	Soft, ductile, pliable, not elastic
1400 to 1000 F	Transforms to pearlite	Soft, ductile, low strength, slightly elastic, somewhat brittle
*1000 to 450 F	Transforms to bainite	Harder than pearlite, elastic, ductile, tougher than tempered martensite
450 to 0 F	Transforms to martensite	Highest hardness, low ductility, low toughness, very brittle
**Reheat to 1200 F	Tempered martensite and bainite	Selective hardness, highest toughness, ductile for given hardness

* Welding condition for "cyclic" welding.
** Condition following completion of "cyclic" welding.

proceeds to bainite if the preheat temperature is held an hour or more. To this point, the weld has been accomplished without formation of untempered martensite which is the most crack sensitive structural phase of the welding cycle. The welding proceeds with high heat input in block welding sequence until a predetermined thickness, 1 to 3 in., of weld metal is deposited.

The block welding helps to retard cooling rates above the M_s line. When the desired thickness of each step of welding is attained, the temperature of the entire cross section of weld and parent metal is raised to the stress relieving range of 1150 to 1250 F. This treatment relieves all residual thermal stresses produced by shrinkage of weld metal, it refines the grain structure and tempers any martensite which may have formed accidentally. The section is cooled slowly to the preheat level M_s + 100 F, and the welding cycle is repeated until the desired thickness increment is reached again followed by stress relief. This cyclic welding and stress relieving sequence is repeated until the entire mass of weld metal has been deposited to any desired thickness. After the weld is completed, the entire section is stress relieved or normalized the last time and cooled slowly to room temperature.

Several observations should be made at this point which reconcile the hazards anticipated at the beginning of the cyclic welding development:

1. All welding is performed at selected temperatures and at cooling rates to avoid formation of brittle martensite.
2. The entire section is repeatedly stress relieved to avoid fractures due to shrinkage opposed by rigid restraint.
3. Low hydrogen electrodes are selected to avoid hydrogen embrittlement.
4. Electrodes are selected which do not contain excessive amounts of elements (principally vanadium) which may result in autocracking, age hardening or precipitation hardness at elevated temperatures.
5. Underbead cracking is avoided by eliminating untempered martensite and by minimizing the contraction of weld deposit between the plastic temperature range and preheat level.

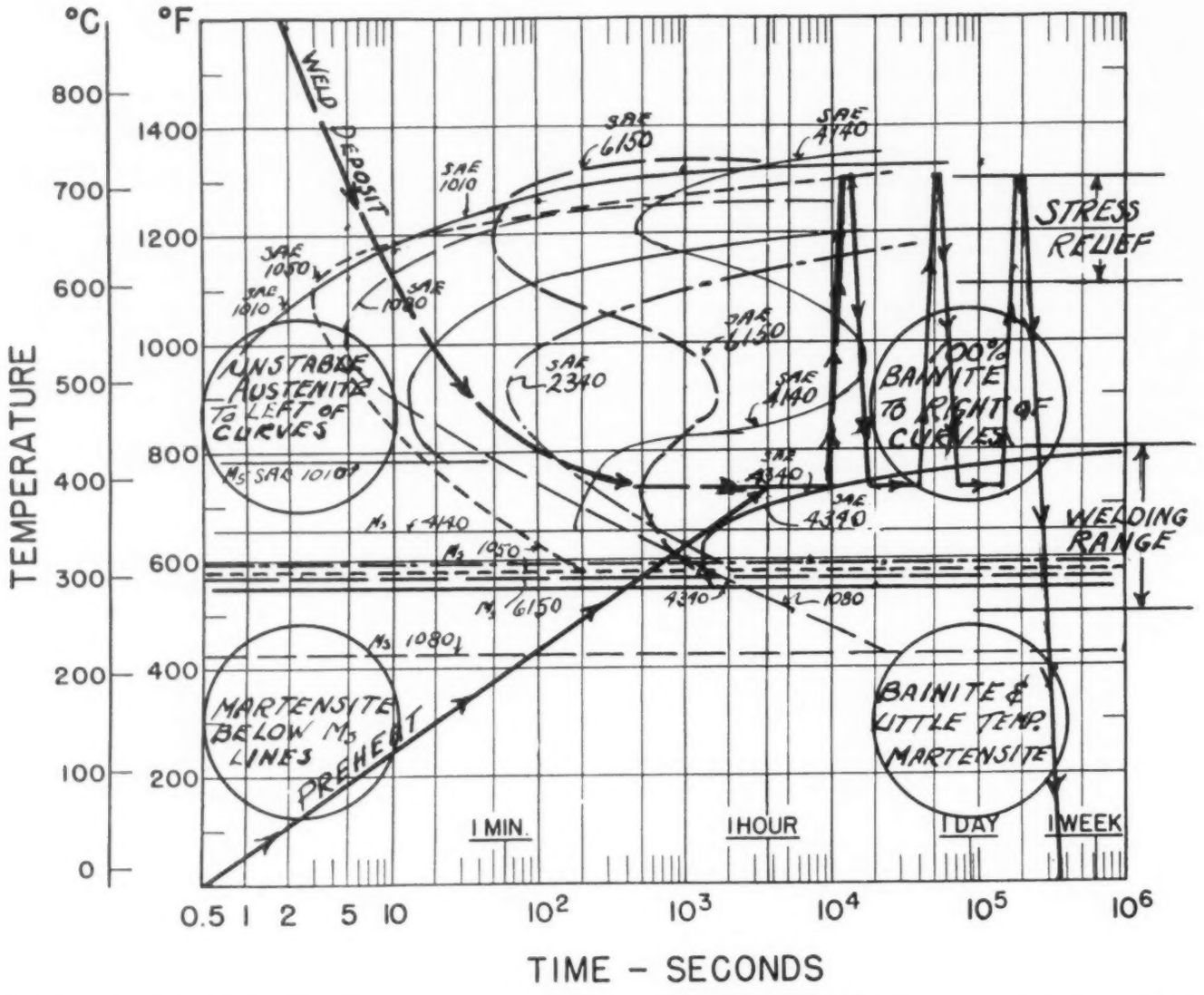


Figure 4 — Isothermal welding diagram for common alloy steels shows favorable heating and cooling rates for cyclic welding.

6. The so-called blue brittle range, 400 to 600 F, is automatically avoided by selection of a preheat temperature of M_S + 100 F.
7. The phenomenon of "creep" is used to advantage in obtaining partial stress relief at high preheat temperature.
8. Distortion can be controlled by the combination of welding sequence, high preheat temperature and frequent stress relief.
9. Slag inclusions, laps and other manual defects can be minimized by requiring all welding to be performed in the vertical position with high heat input.
10. It is believed that all metals are weldable with properly selected materials, conditions and techniques.

CYCLIC WELDING APPLICATIONS

The preceding outline of the welding process executed at controlled cooling rates with precise preheat temperature, with continuous and repeated stress relief, and with rigid supervision of procedure and material selection is the process we identify as the "cyclic welding method."

The cyclic procedure is believed to provide a fool proof weld, unlimited as to mass of weld metal deposit, thickness of members joined and alloy composition of the parent metal. It can be applied in the restrained areas and in any position in the field or in the shop with a minimum of disassembly. Preheat and stress relief can be accomplished by any means of controlling uniform temperatures, but most field repairs are heated by means of temporary gas or charcoal and coke furnaces. Temperature is regulated by control of furnace draft.

Preparation is accomplished by scarfing and cutting to form a 30-degree truncated "V" groove, leaving pillars and some original broken edges to support the parts for alinement. The welding begins in the root of the prepared "V" grooves and continues to a point where experience and judgment indicates that the stress relieving phase of the cycle should be executed. This depends somewhat upon the size and shape of the section and the amount of restraint being worked against. In other words, sections where "free end" conditions exist and where shrinkage is not restrained

can be welded for several inches of thickness without fracturing. In other sections, where there is very heavy restraint or resistance to deformation by weld shrinkage, the welds may fracture after a few passes. Substantial control over this condition can be exercised by heavy peening to stretch the weld deposit, by proper judgment in the amount of heat and areas preheated and by proper use of restraining members. This knowledge is acquired only through experience and a thorough appreciation of the physical effects of temperature upon the metals involved.

When it is considered that a temperature difference of as little as 300 F can cause a fracture and a temperature difference of around 200 F can cause yielding of heavily restrained sections, one begins to appreciate the effects of temperature upon metals and the need for ductility in weld materials. Also, it is important to select weld materials which are not susceptible to embrittlement and subsequent fracturing in the temperature ranges of the welding operation, stress relieving operation or in the final operating conditions.

Welding proceeds after the exact procedure and sequence is studied and prescribed for each case. At this point it should be emphasized that such erroneous procedures as stress relief by torch or other local heat in a restrained area is detrimental and often is the cause of fracture in an otherwise good weld. After the first phase of weld deposit is completed, the entire section is stress relieved, usually by a portable furnace, in such a manner that "free end" conditions are approached. After stress relieving (approximately 1150 F) and inspection by the magnetic particle method, the predetermined preheat is maintained and the welding continues until the desired thickness of weld is reached again. This procedure is repeated in cycles until the weld is completed and a final stress relief and inspection is made.

It should be apparent that this method avoids building up of harmful residual stress at any time. Since the shrinkage occurs in the outer fibers of the weld, all internal fibers are in a state of compression and if fractures should occur they can only occur in the outer fibers where they can be seen during inspection. Experience also has proved that where safe welding limits are exceeded and fractures occur, they extend only to the surface stress previously relieved and correction is easily accomplished by a small amount of rewelding.

A typical flaw in a 100-ton cast steel upsetter frame is shown in Figure 5. This defect is a shrinkage cavity or gas pocket about 5 in. diam and several feet long near the point of maximum stress of the upsetter throat. The 24-in thick section was effectively repaired using about 750 lb of 100,000-psi tensile strength weld metal to fill the void and reinforce the section. This type of subsurface flaw is frequently the source of failures in large cast steel sections such as hydraulic press cylinders and machine frames. A secondary observation made in analyzing these failures is that the same allowable design stresses were used in the original design of the casting as would be used in forgings or rolled steel of the same composition. Since this condition has been observed in a large number of failures and the presence of gross voids by ultrasonic tests of new castings has also been confirmed, it is believed that the design practice of assuming large castings to be of equal strength to forgings is a fallacy in machine design. This fallacy

Figure 5 — Scarfed section of a 100-ton cast steel upsetter frame shows gross shrinkage cavity.

could be remedied by adopting more realistic allowable stresses in designing castings and by ultrasonic inspection of critical areas of new castings.

Development of the cyclic method is of particular interest to designers of heavy weldments, machine frames, hydraulic presses and ship frames as well as to maintenance engineers because it provides an efficient means of joining massive forgings and castings which are too large to form from a single ingot or foundry melt. This problem presented some limitations in producing large hydraulic presses for government aircraft forgings a few years ago. A few of the successful appli-

Figure 6 — This illustration of a large hydraulic forging press is marked to indicate location of typical repaired areas.

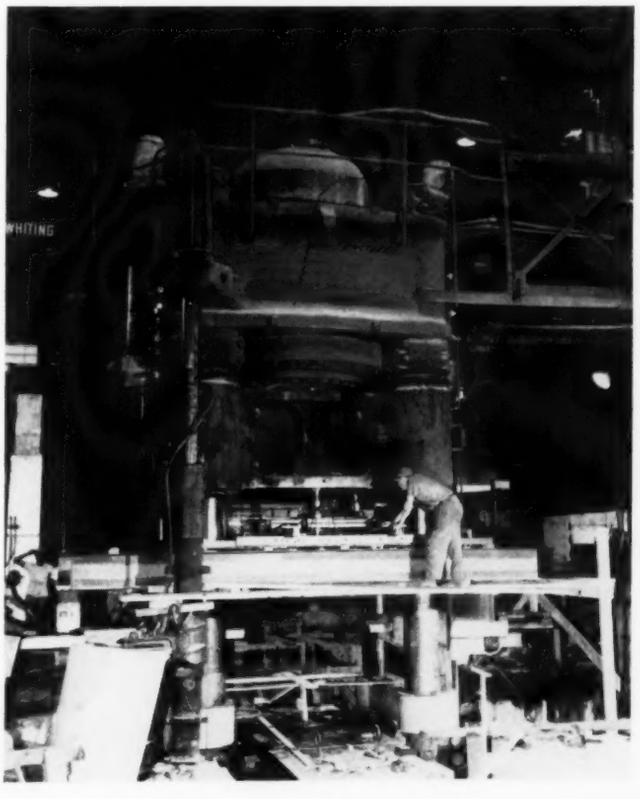


Figure 7 — This 35-ton cast steel alligator shear housing was repaired by welding a fractured section measuring 22 x 34 in.

cations in maintenance repairs have been location welding of large hydraulic forging press cylinders, columns, rams and bed plates illustrated by Figure 6. The 35-ton cast steel alligator shear frame shown in Figure 7 was broken through a section approximately 22 x 34 in. This repair was completed at about 15 per cent of replacement cost with a savings of several months in production loss.

A large number of reversing blooming mill spindle universal pods, as the one shown in Figures 8 and 9 have been welded at less than half the cost of the previous method of forging new pods and thermit welding to the shank of the spindle. A number of blooming mill shear blocks have been welded similar to the 50-ton steel castings shown in Figure 10 which was of 0.50 carbon steel. Other applications include forging hammer anvils, rams and frames; upsetter frames, alloy crankshafts shown in Figures 11 and 12; cross slides; mill housings similar to Figure 13, roll and pinion necks; large gear spokes, teeth and rims; high-speed turbine and fan shafting and ship propeller shafts.

Many of the items were of forged and cast steel compositions up to 0.70 per cent carbon and in alloys equivalent to SAE 4140, 4350 and 6140. Section thickness in many cases was over three ft. In all of these repairs extending over a 5-year period recurrent failures have been practically nil.

Some of the reasons for these excellent results are:

1. Critical areas can usually be welded with a sound weld material of high strength replacing a weaker material which often contains an obvious flaw.
2. Large fillets can be formed to replace sharp corners and other stress risers.
3. Areas subject to tension can be prestressed by peening and prestressed in compression to alleviate recurrent failure in tension.
4. Design changes can be incorporated to provide reinforcement where desired and to provide improved design features.
5. We are assured of complete stress relief which would restore the original stress relieved conditions and would eliminate possibility of other highly fatigued areas which may have developed during the operating history of the equipment.

Figure 8 — Broken reversing mill spindle pods similar to the 20-ton SAE 4340 spindle shown are welded without difficulty.

Figure 9 — Welded spindle pod of Figure 8 was reclaimed at less than one-half the cost of a new unit.

The patented cyclic welding service is available in any location to industry on a contract basis as well as by license agreement.

In conclusion, it is felt that a new plateau has been reached in the development of metal joining techniques and a wide range of applications lies ahead in fabrication, in manufacture of large machine parts, and repair of heavy alloy steel sections.

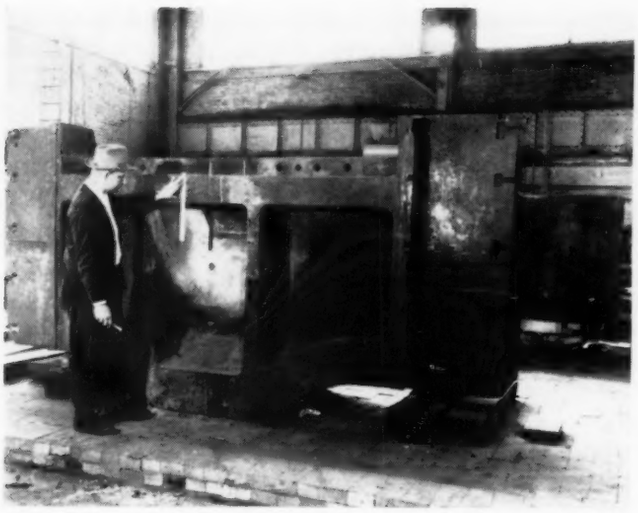


Figure 10 — This 50-ton SAE 1050 steel shear blade casting was broken about 50 per cent through the heavy section and restored by cyclic welding.

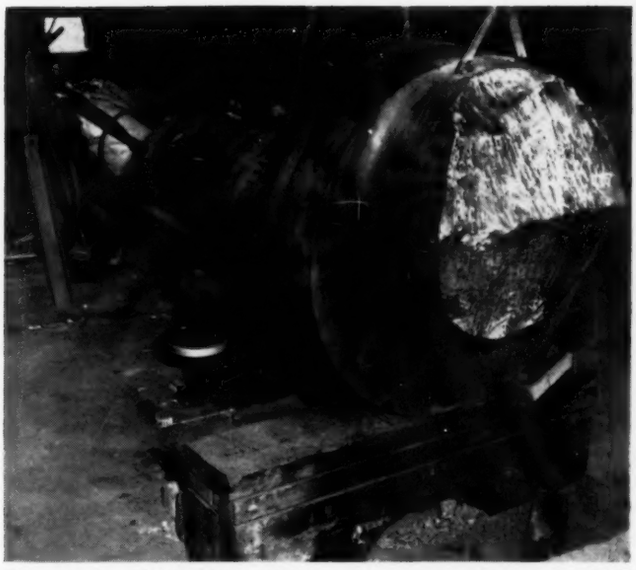


Figure 11 — Tnis 22-in. diam upsetter crankshaft of SAE 4140 was restored after complete failure.

Discussion

PRESENTED BY

J. H. DILLON,
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Construction and Maintenance Dept.,
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R. A. KRAUS, Superintendent,
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ROBERT C. PULTZ,
General Superintendent, Maintenance,
Lorain Works, National Tube Div.,
United States Steel Corp.,
Lorain, Ohio

J. H. Dillon: Our plants have had several pieces of equipment successfully repaired by this process at a considerable saving in time and money. It is extremely difficult and unwise to argue against success.

There is one part of this process which I believe the author did not adequately emphasize, and that is "experience and judgment." The mechanics and the metallurgy of a metal of known analysis can be accurately predicted and controlled under conditions which are known and controllable. However, in the repair of heavy equipment some of the factors involved are almost as unpredictable as are the time and location of the failure itself. Since the cyclic welding method depends largely upon the proper application and control of heat, it is the factors affecting heat control which are particularly important. Irregular fractures, intricate cross sections, thickness differential between adjacent sections, porosity and degree of saturation of castings have an influence on heat absorption, heat transfer and heat loss.

The evaluation of these factors in any given situation and the determination of the proper procedure is a problem of almost infinite complexity and is more of an art than an exact science. It is here that the rather

* At time of paper presentation.

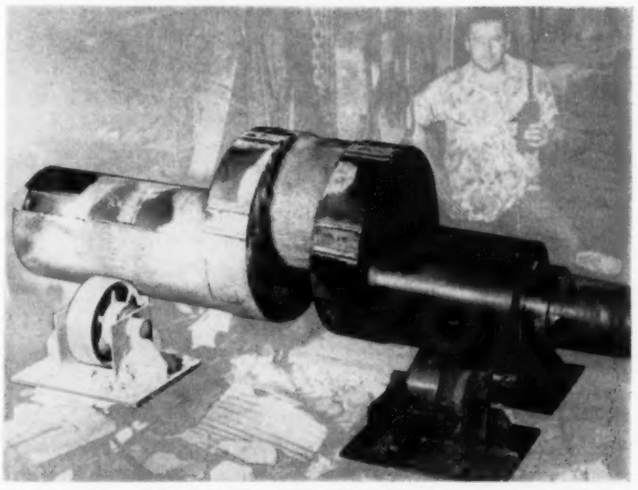


Figure 12 — Crankshaft of Figure 12 after cyclic welding.

Figure 13 — A number of mill and pinion housings similar to the one pictured have been repaired after complete failure of both columns.

indefinite and elusive qualities of experience and judgment play an important part. The success which has been experienced with the cyclic welding process in many and varied repairs is sufficient evidence of the high quality of experience and judgment which has been applied.

I have two questions: first, is any difficulty experienced with embrittlement or stress concentration in what might be called the transition zone, that is, the section somewhere between the welded area, which is stress relieved or normalized, and the areas which are not heated or affected by the heat, that is, in the parent metal? Second, in this process in which so much depends upon maintaining temperatures above critical M_s lines, is there any merit in the use of automatic or continuous welding heads with their high rate of metal deposit and high heat input? It would seem, both from a time and heat standpoint, to be an advantageous method of depositing the weld metal.

R. L. Rectenwald: To answer the first question, I believe that you are referring to the transition temperature between the actual welded area and parts distant from the weld.

In structures such as a closed type mill housing having a fracture through one corner, you probably encounter the most severe stresses caused by preheating one section and stressing another section due to the thermal expansion differential.

In a case like that, we design the furnaces so that there are two furnaces opposite each other, and in this manner we would simulate free end conditions so that the welded portion would expand and contract the same amount as the opposite section, and this can be done by controlling the temperature and adjusting the length of the area heated.

Now, as for any transition zone effects caused by the stress relieving, we are normally within the temperature range where drawing or tempering would have been performed. We are not going above the upper critical, and for this reason we are generally not affecting the phase structure, strength or physical properties of adjacent portions.

We would like very much to have an all-position, automatic welding machine. If you can tell me where to obtain such a machine, I would be interested. That is the most difficult feature of maintenance welding and most of the automatic welding machines can only be used in the downhead position. Most of this work has to be welded in other than downhead positions.

Automatic welding on very heavy sections does not usually generate sufficient heat to hold the entire cross section at a temperature above the M_s line, nor does it approach stress relieving temperature throughout.

The need for auxiliary preheat would depend upon the thickness and mass of metal adjacent to the welded area. Our goal is to maintain uniform preheat temperature throughout the entire cross section containing the welded area. Heavy sections of cold metal adjacent to the weld would absorb heat from the weld zone and could cause rapid quenching resulting in cracking due to brittle martensite formation and uneven shrinkage. For this reason, we always use auxiliary preheat even with automatic welding heads in order to reduce the quenching phenomenon and to minimize shrinkage differential. As an example, when welding large mill spindles or mill housings, auxiliary preheat is used and the entire section is stress relieved at about 1150 F with each 3-in. layer of weld deposit.

J. H. Dillon: The question is would automatic welding heads be advantageous.

R. L. Rectenwald: They would be advantageous where applicable. Another limitation I have found is that we cannot obtain sufficient variety of materials in wire of the desired physical properties, particularly in the high alloys. Wires are available in low carbon steels, but the supply is limited in higher alloys, above 100,000-psi tensile strength, and in tool steel grades.

R. A. Kraus: Inasmuch as a considerable part of this welding is performed with temperatures of the work piece at 700 F and knowing the discomfort of the welder under these conditions, I would appreciate hearing about the arrangements that are made to control this factor.

If your welder is continuously working under unsatisfactory conditions, the quality of the weld he produces would be under suspicion.

R. L. Rectenwald: Some of these welding operations would look very much like a hospital patient stretched out on the operating table covered up with white sheets. We generally cover the entire area of hot jobs with asbestos cloth, or felt magnesium block and also with the aluminized sheeting materials. Sometimes our welding operators use the aluminized jackets and sleeves, gloves and helmets. Generally we cover the hot areas and remove just enough of the insulation so that we can perform the welding. The insulation cuts the radiant heat sufficiently that the operators do not require any special heat reflecting clothing. The aluminized fabric made up into sleeves and jackets has been very beneficial in reducing radiant heat upon the operators. I do agree with Mr. Kraus that operator comfort is a necessary consideration in obtaining quality welds. We do not leave quality to chance, however, because all welds are tested by magnetic particle method or ultrasonics to assure quality.

Robert C. Pultz: One question I would like to ask is this: when you are scarfing, preparatory to welding, what precautions do you take so far as preheating and stress relieving to prevent formation of a martensitic structure?

R. L. Rectenwald: On all of the high carbon, high alloy steels we would normally preheat above the M_s line to the welding temperature shown on Figure 4 before scarfing. If we did not take this precaution, we would expect rapid quench and formation of martensite in the scarfed area. In addition, severe expansion is caused ahead of the scarfing torch and this results in spreading of the fractured metal and propagation of the fracture while scarfing.

Robert C. Pultz: Do you follow that by stress relieving in case you did get any martensite formed before welding?

R. L. Rectenwald: We do not usually stress relieve following scarfing if welding is to follow immediately. Since the parent metal has been preheated above the M_s line before scarfing we would not expect to form martensite. In the process of welding at the same high preheat, the surface structure would undergo the transformation changes predicted by Figure 1. If the part is allowed to cool before welding, we would

normally stress relieve high alloy materials following scarfing.

Robert C. Pultz: I do not know whether you necessarily call this cyclic welding or not; but in the process of cyclic welding or other welding, do you ever use an austenitic deposit such as stainless steel either in cyclic repairing or in the case of repairing a slipper fit in a universal coupling where you want to get some benefit from the hard-working properties of austenite in the built up fit? Now, in that case, can you go ahead and do the regular preheating and stress relieving without getting carbide precipitations in your stainless or austenitic deposit? Or if you do get carbide precipitations, would that affect your ductility and toughness of your deposit?

R. L. Rectenwald: I am not a firm believer in the use of austenitic steel filler metal in performing welds of that type because I do not think that the cost is justified. Also, I do not believe we obtain sufficient tensile strength or yield strength at the fusion line by the use of austenitic steel filler metal for a strength weld of high alloy steels.

As far as carbide precipitation is concerned, I doubt that the carbide precipitation would affect the strength materially. Of course, it does affect the corrosion resistance, but we are not interested in that property of the wear resistant welds in mill machinery.

Also, as for build-up for wear resistance, I feel that there are less expensive materials of high alloy which will give us equal or better wear resistance than some of the austenitic alloys.

We do have one disadvantage in stress relieving following the build-up of hard surfacing materials, in that in the process of stress relieving we are also drawing the hardness from the hard surfacing material so we are gaining in toughness in one case and losing hardness in another at the same time, so possibly there is some compromise where, after stress relieving, we could hard-face at a lower preheat temperature and retain more hardness in the finished surface.

In the case of mill spindle and coupling slipper surfaces built up cold with hard facing rods and austenitic filler material, we have detected small fractures at the fusion line which would contribute to failure particularly in high alloys and deep hardening materials such as SAE 4340. Perhaps a better procedure would be to undercut the slipper surfaces by machining and overlay the parent metal with one pass of low alloy filler metal followed by stress relief and then deposit the final surface with hard surface material without stress relief.

Robert C. Pultz: What about the machining, if you are building up something where you have to machine? Your hard-surfacing material would be prohibitive on that account, would it not?

R. L. Rectenwald: Not necessarily because we have found quite a range of hard-surfacing alloys with which we obtain between 250 and 400 Brinell, which is machinable, and gives excellent wear resistance. Another possibility would be to follow the procedure described previously and flame harden after machining. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering, and so forth should be directed to that address.

1229 VARLET, J.: "Care of Rolls for Hot Rolling Thin Sheets," *Rev. Univ. Mines*, 1945 Sept. 15, pp. 118–121. (Abstract J.I.S.I., 1947, Dec., p. 638: The author indicates precautions which should be taken to prevent the premature fracture of quenched cast-iron rolls, and emphasizes the importance of the direction of rotation of rolls which should not be left to chance, and gives details of the maintenance needed before and after rolling, with special emphasis on the cooling period of rolls.)

1232 GERLACH, E.: "Roll Cracking in Sheet Mills," *Met. u. Giessereitechn.*, 1952, Jan. pp. 14–17. (Abstract J.I.S.I., 1953, Apr., p. 445: The causes of fracture of rolls used for hot-rolling are discussed. Recommended practices for their use and care, which are likely to minimize breakages, are given.)

1253 LATOUR, A., and J. SCHOOP: "Vibration Method for Preparing Converter Linings," *Stahl u. Eisen*, 1953, Jan. 15, pp. 81–84. (Abstract J.I.S.I., 1953, June, p. 168: A new and simple method of preparing tar-dolomite converter bottoms is described. In this, a large number of hollow tubes or "needles" are placed in the mixture on the converter base and slowly withdrawn as the mixture is consolidated. A plate, carrying a securely mounted electrical vibrator, and having a series of holes corresponding to the needles, is lowered over these. The action of the vibrator rapidly compacts the tar-dolomite, the needles serving to allow air to escape. The resulting bottom is superior in wear resistance to those prepared by ramming.)

1269 FROLINGHEUER, K.-H.: "Steelworks Cranes from the Work Study Point of View," *Fordern u. Heben*, 1958, Feb. pp. 58–61.

1071 ZUR, M.: "The Water Supply System of the Hoesch-Westfalenhutte A.G., Dortmund," *Stahl u. Eisen*, 1958, Aug. 21, pp. 1191–1200. (Abstract *J.I.S.I.*, 1959, Feb., p. 204c: The total water consumption of the works is about 33,000 cu meter per hr. All the water is recirculated and treated before re-use. Plant and equipment for the treating of the water is described and the cost discussed. The purchase of mains water could thus be reduced to about 650,000 cu meters per month. For emergencies, diesel engines for pumping the recirculated water are to be preferred to storage tanks.)

by Louis A. Stanzione, Engineer

Williamsport Plant, Bethlehem Steel Co., Williamsport, Pa.

An Approach To Wire

. . . . suitable lubricant properly applied in the manufacture of wire rope and during its service life will preserve its physical strength and increase its service life . . . .

JUST as lubrication is necessary for the proper operation of any machine so is it necessary for the proper functioning of an operating wire rope.

Wire rope is a rather complex piece of machinery composed of numerous moving parts, each designed to perform a specific job. Any attempt to discuss the problem of lubricating wire rope would not be complete without first studying its design and construction.

Wire rope is made from cold drawn, carbon steel wires which are first arranged helically into what are called strands. The strands, generally six, although other numbers may be used, are arranged helically around a core. Figure 1 shows a few typical cross-sections of wire rope.

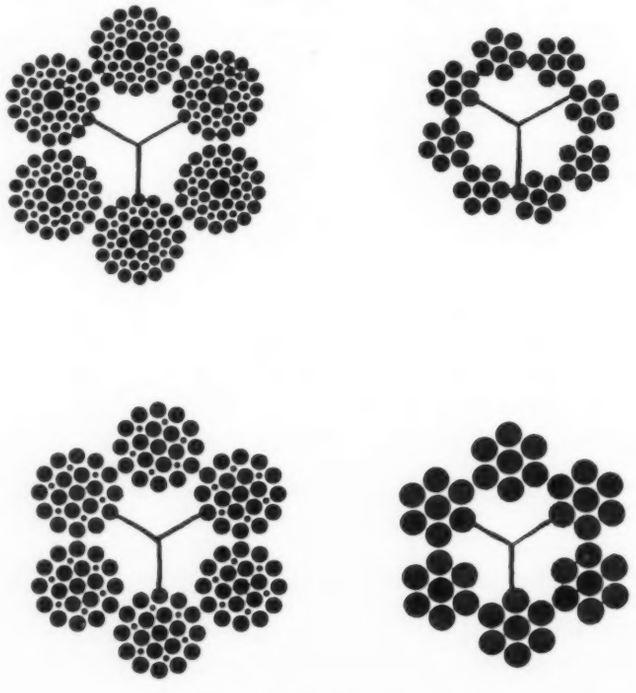
The number and arrangement of the wires in the strand and of the strands in the completed rope are governed by the ultimate use for which the rope is intended, while the relative sizes of wires and strands must be determined by careful engineering layouts which provide proper proportions as well as clearances between the component parts. This is important as a wire rope usually is a moving part of machinery, the life and performance of which in a large measure depends upon freedom of movement of the individual parts. For this reason lubrication of wire rope, during fabrication and while in service, is a very important factor.

The conditions under which wire rope must operate are very important from the standpoint of selecting a lubricant. These conditions are many and varied, ranging from the comparatively clean, dry conditions in the case of elevator ropes to the dirt, dust and corrosive fumes of a steel plant. Also encountered are the severe abrasive conditions in the heavy construction field where the ropes are often dragged through rocks, dirt and water. In these various services, the rope also must operate under the extremes of temperature such as the heat of the West Texas drilling fields to the cold of the Wyoming and Colorado area.

The selection of a lubricant to perform satisfactorily, initially, under all these conditions is one of the basic problems confronting the wire rope manufacturer.

Up until recently little or no laboratory testing of wire rope lubricants was conducted, and these products were often bought and used on the recommendation of

Figure 1 — Typical cross-sections of wire rope.



Rope Lubrication

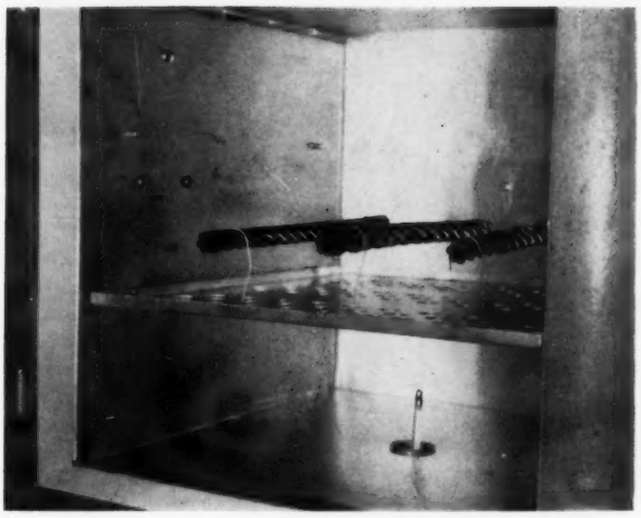


Figure 2 — This oven is used to test the lubricant's ability to withstand high temperatures without dripping or flowing.

the lubricant supplier; their ability to perform satisfactorily was never known until they were actually tried under field conditions. Six months or even a year could easily elapse before sufficient rope was put into service and the necessary field reports were received to evaluate the performance of the lubricant. By then many thousands of feet of wire rope could be in warehouses and in use, and if the lubricant proved unsatisfactory it could result in a considerable number of complaints and expense to the rope manufacturer.

In order to minimize or prevent this condition, the Bethlehem Steel Co. embarked on a program to develop some laboratory or bench tests with the hope that through these tests the eventual field performance of a lubricant might be predicted.

Of primary concern was the lubricant's behavior under high and low temperatures and also its ability to wet the wire surface sufficiently to give the necessary adhesive characteristics required and thus prevent any stripping of lubricant from the rope.

To check the lubricant's ability to withstand high temperatures without dripping or flowing from the rope, the test shown in Figure 2 was devised. A small length of wire rope is coated in the laboratory with the lubricant being tested, and then allowed to set for a period of 1 to 2 days. The rope is then placed horizontally in an oven and subjected to periodic increases in temperature until such time as the lubricant drips. At this point the test is concluded and the temperature noted.

The low-temperature behavior of the lubricant is checked using a sub-zero cabinet as shown in Figure 3. Approximately 2-ft lengths of wire rope are coated with the lubricant under test and after setting from one to two days the samples are placed in the working chamber of the sub-zero test cabinet. Cooling is accomplished by circulating air through dry ice. Temperature is controlled by a thermo-regulator which energizes either the cooling blower motor or the electric heater, as necessary. A circulating fan in the work chamber ensures even temperature throughout this chamber by thoroughly mixing the air, and blowing air over the heater coils. This cabinet has a temperature range of −100 to +200 F. After being subjected to the desired low temperature for 24 to 48 hours the ropes are removed and checked for flaking and cracking of the lubricant by flexing the rope as shown in Figure 4. This test is carried out at a temperature of −20 F and lower.

In conducting this test an attempt is made to maintain, as nearly as possible, the same film thickness of lubricant on the test specimen as is applied on the rope during manufacture. This is important because there is a relationship between the film thickness of the lubricant and its ability to resist cracking and flaking.

Figure 3 — The low-temperature behavior of the lubricant is checked using the sub-zero cabinet shown.

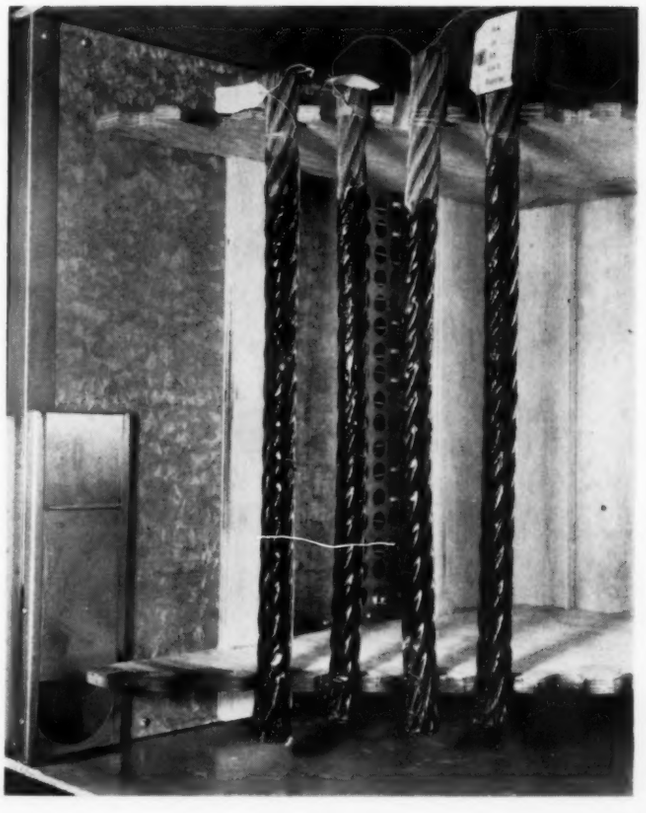


Figure 4 — After being soaked in a sub-zero temperature the ropes are flexed to check for lubricant cracking.

During manufacture of the wire rope very definite means are employed to insure proper film thickness of the lubricant, depending on the end use of the rope. Wipers generally consist of such materials as sheepskin, rubber and fiber depending on the type of wipe desired.

It is not uncommon for wire rope lubricants to crack or flake under these test conditions and depending on the severity of the cracking or flaking of the lubricant is passed or rejected.

Another major concern is to prevent any stripping of the lubricant from the wire rope during unreeling, as shown in Figure 5, or while the rope is in use. Entering into this test is the rust preventive used on the finished wire during storage and prior to its being made into a wire rope. The wire rope lubricant must be able to overcome any film deposited on the wires by the rust preventive to insure proper adhesion.

Figure 5 — A major concern is the preventing of lubricant stripping during unreeling. A severe case is shown.

This adhesiveness or stripping test is conducted by using steel strips $^{3}/_{64}$ x $1^{1}/_{4}$ x 13-in. which are treated with the rust preventive in use and then allowed to set for two to five days. The strips are then coated with the lubricant under test and allowed to set for 48 hr. At the end of this time the strips are pressed together as shown in Figure 6, and then separated. Figure 7 shows the results of a test where the lubricant has been stripped down to the bare metal. Figure 8 shows the results of a successful test. In one case this test proved quite valuable in that it clearly showed that the rust preventive being used would not allow the lubricant to adhere to the metal. This test is now used in both testing new rust preventives as well as lubricants with respect to adhesiveness.

The question uppermost in most minds is probably, "How reliable are these simple bench tests in predicting field performance of the lubricant?" The writer can best answer this by stating that approximately $3^{1}/_{2}$ years ago we subjected two new wire rope lubricants, as supplied by a major oil company, to these tests. As a result of these tests we chose one of the products and put it into full-time field use. To date not one complaint has been received on this lubricant. Since then two other products have been accepted on the basis of these tests, and they also have proved very satisfactory in the field. On the other hand a number of products on the basis of these tests have been rejected. This brings to mind the case of one lubricant, submitted by a major oil company, which, when subjected to the high temperature test, dripped from the rope at 95 F. Imagine the complaints we would have been faced with had we accepted this lubricant strictly on its physical characteristics and the lubricant supplier's recommendation.

In another instance the validity of our low temperature test was proved when a product was rejected because it had failed this test at 8 F. However, the oil company involved was not satisfied with our results since their own low-temperature laboratory test had cleared this product for −40 F. Therefore they wanted to conduct a field trial for which they were willing to purchase a rope lubricated with their product. This was done and when the rope was placed in service the lubricant failed at 32 F.

Passing these rather simple but effective bench tests is the first of three hurdles which a new product must surmount before being accepted.

The second hurdle is that the lubricant must be adaptable to the shop application methods. This is checked by subjecting a small quantity, usually five to 10 drums, of the new lubricant to our normal production methods. Basically, this consists of melting the lubricant from the drum in large preheat tanks in the oil room where it is maintained at the proper temperature. From here it is distributed to the various stranding and closing machine lubricant tanks from which it is pumped into the wire rope. Hot application type products are readily handled in this manner.

There are, however, occasions when it is required that a cold application lubricant be used, and this does pose certain problems such as those associated with pumping and returning the lubricant overflow to the reservoir from which it is pumped.

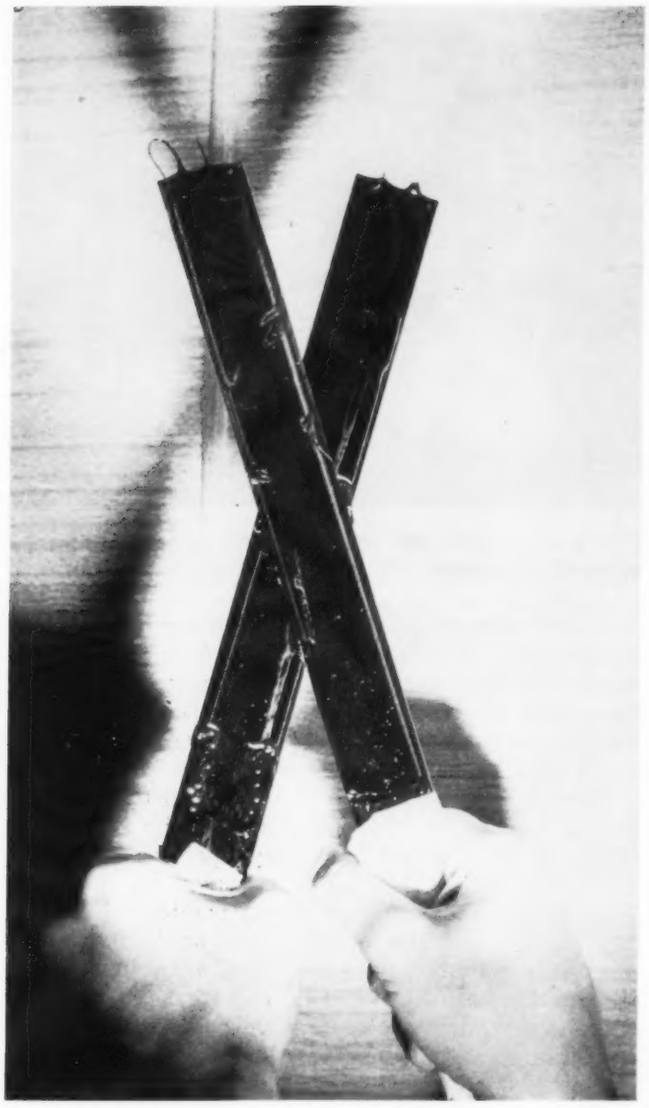


Figure 6 — After a 48-hr set period the coated strips are pressed together.

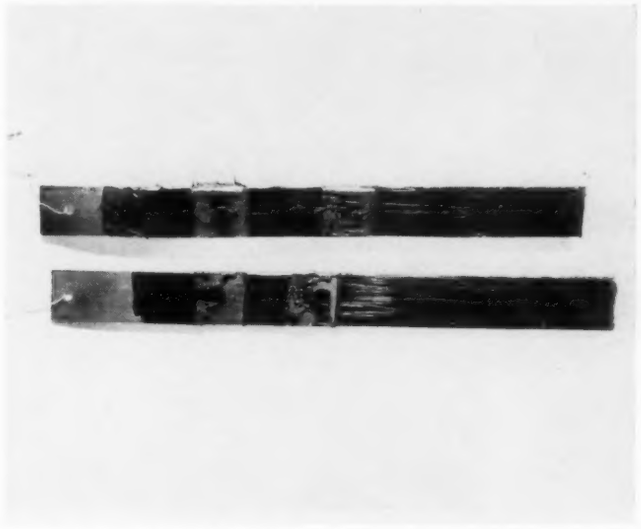


Figure 7 — These steel specimens show the stripping of lubricant from touching them together.

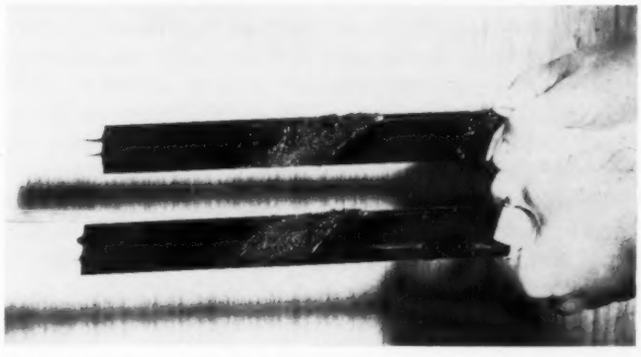


Figure 8 — Lack of lubricant stripping on these steel strips indicate good adhesiveness for the lubricant.

If all goes well during this second phase, the lubricant is placed in production for approximately a month and field results are then ascertained. This procedure was followed when this test program first went into effect, but as a result of the very favorable correlation between the tests and field results it is now possible to use new lubricants on a full-time production basis if they pass the bench tests, thus eliminating any lengthy period of field testing.

After the lubricant has been accepted and put into use, it is vitally important that it be applied to the ropes in a manner that will preclude any destruction of it by overheating. This can be done by making use of permanently mounted thermometers on the melting tanks and also the use of accessory equipment, such as agitators, if necessary. Figures 9 and 10 show this equipment in use.

The writer is aware that these tests are only suitable for checking certain characteristics of a wire rope lubricant and are of no use in determining whether one lubricant will give longer rope life than another or whether an extreme pressure additive is beneficial or not in a wire rope lubricant. These properties can best be determined by field tests or possibly in the laboratory by the use of some type of fatigue-testing machine. In judging whether one lubricant will give better rope life than another by the use of field tests, one must be very careful since in most wire rope applications there are many, many variables involved, which, if not properly analyzed, could easily give a distorted picture of rope life and lubricant performance.

Now that the wire rope manufacturers' role in the lubrication of rope has been covered, consider another and equally important phase of wire rope lubrication—lubrication of the rope while in use, or so-called field lubrication.

It is during the process of fabricating the rope that all the individual wires can be given a coating of lubricant which in a number of instances will be the only lubrication received by some of the inner wires during the life of the rope. This could be due to a number of factors such as unsuitable field lubrication facilities, disregard of the importance of a planned lubrication program, and just plain neglect. Figure 11 shows lubricant being applied to the strand during fabrication.

Even if the wire rope manufacturer applied the best lubricant available during the fabrication of the rope, this would not suffice for the life of the rope since loss of lubrication begins as soon as the rope starts to work and this loss of lubricant must be replaced by some method of field lubrication.

There are numerous products as well as ways and means of applying field lubricants, and no attempt will be made to expound on this matter in this paper.

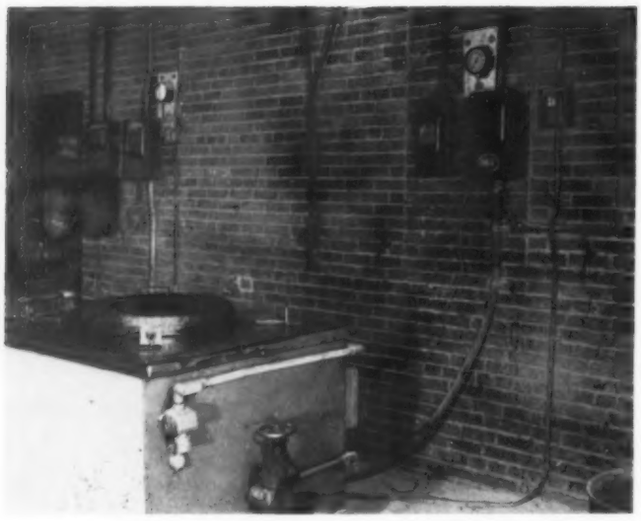


Figure 9 — The lubricant-melting tank is equipped with a thermometer to preclude overheating.

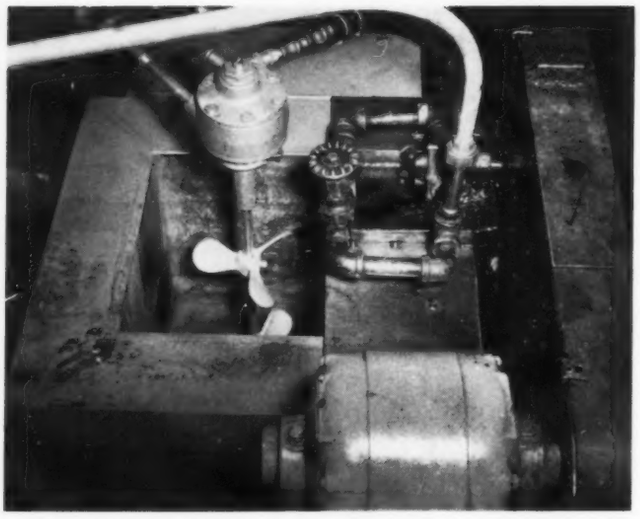


Figure 10 — Inside the lubricant-melting tank is an agitator which insures temperature uniformity.

Of course, lubricating a rope regularly during its use is not going to assure as much rope life as someone gets on a particular application, such as a blast furnace skip hoist. In an operation such as this, there are many other factors involved which have a great influence on rope life such as size of sheaves, skip capacity, etc.

Recently a survey of lubrication practices on wire rope was conducted throughout the various plants of a large steel company. Even though all of the plants maintained a definite program of lubricating their skip hoist ropes, the life of these ropes varied considerably from one plant to another. For instance, one plant lubricated its ropes once a week and was getting about nine-months service whereas another plant was lubricating twice a month and getting about 30-months service. It is quite obvious that in a case such as this, other means for improving rope life must be explored.

The important thing to remember is that wire rope, just like any other working piece of machinery, should and must be lubricated during use if it is expected to give maximum service.

Discussion

PRESENTED BY

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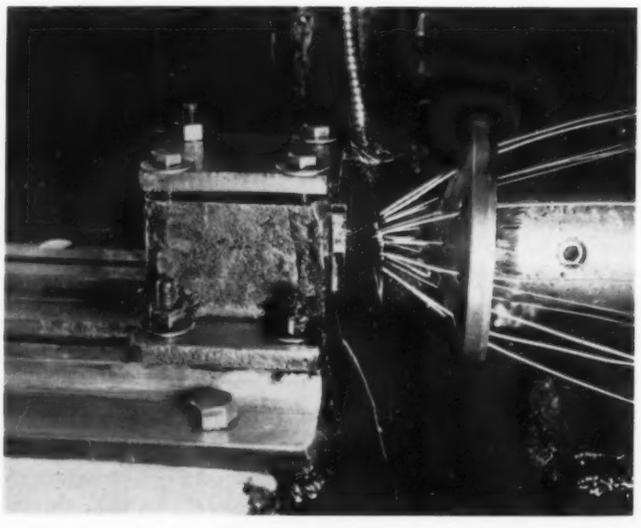
D. E. Brown: The procedures described for selecting suitable lubricants for application to wire rope during its manufacture, by means of appropriate bench tests, are also representative of what is being done in the laboratories of the American Steel & Wire Div. of U. S. Steel. This should, therefore, drive home the point of the awareness of the wire rope manufacturer's responsibility to the customer for selecting proper lubricants for application to the ropes they purchase.

The need for a lubricant to be applied to wire rope during manufacture can be illustrated by giving the results of some recent actual tests performed on aircraft cord that was being investigated for a special application of control cord on jet bombers. Here the problem was to find a lubricant that would help retain the rope's bending fatigue properties when subjected to temperatures of 500 to 700 F. Various metallic-coated carbon steel wires such as drawn galvanized and tin and stainless steel wires were selected. Then, test ropes were made with and without an application of lubricant during manufacture.

After subjecting these cords to various bending cycles, a breaking strength test was made of the test sections to evaluate the seriousness of the loss in strength of rope which had lost its lubrication in service. For 70,000 bending reversals of the cords over sheaves as pre-

Figure 11 — Lubricant is being applied to the strands during fabrication.



scribed in U. S. Government Specifications, the remaining strength in per cent of actual strength for lubricated versus unlubricated cord was measured. It was found that the strengths dropped from 77 to 43 per cent for the drawn galvanized cord, from 82 to 51 per cent for the tinned cord and from 77 to 39 per cent for the stainless cord.

It is believed the figures just given illustrate and emphasize most effectively the need for a lubricant to be applied to ropes in manufacture and the need for an adequate treatment of lubricant to rope in service.

I feel that it would be of interest to mention more about the types and characteristics of the lubricants used by manufacturers of wire rope, and with this purpose in mind, the following comments are offered.

Practically all wire rope lubricants used for wire rope are of a grease type and fall under two general classifications: those made from a petrolatum base and those that are asphaltic in type. As far as the American Steel & Wire Div. is concerned, our choice for general hoisting conditions, other than for elevator hoisting, has been the asphalt type because we feel, after it has been applied hot, at temperatures ranging from 200 to 250 F it sets up firmly around all the wire surfaces, and will best resist being rubbed or washed off during rope transportation, storage and rope service life.

Such material has to act as a protection against corrosion as well as act as a lubricant and, therefore, it has to have good corrosion resisting properties as well as good lubricating properties. Our aim, as is the aim of all wire rope manufacturers, is to select that material which develops the greatest number of physical properties relating to both protection and lubrication, combined with its capabilities for withstanding very low and very high temperatures.

For ropes to operate on elevators, an elevator rope lubricant has to be compounded to meet specifically those conditions associated strictly with elevator use. This material is a petroleum oil with soap and rosin and rust inhibitor additions. It must set up and be sufficiently tacky on the rope to prevent slip of the rope on traction U-groove drums, and it must be applied in such a degree that no excess lubricant will build up on the elevator sheaves or drums and drop off during operation of the rope on the elevator installation.

For general hoisting ropes requiring the asphalt type lubricant, the type of hoisting conditions involved govern the amount of lubricant to be applied to the strands or completed rope. A severe hoisting condition involving corrosion is provided for by applying a heavy coat of lubricant at the stranding machine and then passing the completed rope through a bath of the same lubricant at the closing machine, or in a separate operation prior to shipment of the rope. By applying what we term a medium, heavy or extra heavy coating of the asphalt type material, both lubrication and protection are provided, for any type of rope service. All wire cores closed into our hoisting ropes are treated with the heavy asphalt type compound during both the stranding and closing of the core. Most fiber cores closed in hoisting ropes, other than elevator ropes, are also run through a bath of the compound before or during the closing of the wire rope.

It is desired to mention here, as also indicated in the paper, that the lubricants used are selected only after a great deal of experimental work has been done in collaboration with the personnel of leading oil companies.

For concluding comments, I should like to elaborate a little more extensively upon the need for supplementary lubricant to be applied to ropes in service. Although it has been described how ropes are lubricated during fabrication, with the amount and grade of lubricant depending upon the size and type of rope, this initial lubrication is seldom sufficient to last the useful life of the rope. Therefore, periodic applications of oil or grease of the proper consistency will be required. The importance of periodic lubrication is understandable when it is appreciated that each time a rope bends or straightens, the wires in the strand and the strands in the rope must slide on each other. For a rope to give satisfactory life, a film of lubricant must be ever present on each moving part.

If a rope is corroded or rust-bound, freedom of movement of the wires in the strand and strands in the rope is interfered with, resulting in premature breakage of individual wires and even strands in the rope. There is no standard equipment used in the field for lubricating wire rope and the lubricant that is applied is done so by any means suitable to field conditions. It may be brushed onto the rope with a stiff brush, applied by passing the rope through a trough or box of lubricant, or the lubricant may drip onto the rope, preferably at a point where the rope opens slightly from bending.

There are, in general, two classes of field lubricants. One type is a heavy consistency material that has to be heated before it can be applied to a rope, and the other type is a free-flowing material in the cold state which allows it to be applied at normal outdoor temperatures. Of course, the consistency of the lubricant used must be governed by the condition of the rope receiving the treatment. For ropes caked with dirt and contaminated stiff grease, a thin penetrating type oil should be used first in order to insure getting the lubricant to reach the innermost wires and the core. After getting such rope thoroughly treated, a protective coating of heavy type material can be applied. The maintenance foreman or superintendent should be in the best position to know when his ropes need lubrication and the type of lubricant that will be most effective.

For one specific maintenance engineer's experience as regards getting maximum rope life from improving his rope lubrication practice, reference is made to an article written by A. F. Meger of the Hanna Coal Co., which appeared in the magazine *Coal Age*, June, 1955. He found that the biggest factor contributing the most to shovel rope life was the installation of a good lubricating practice and lubricating equipment.

J. E. Grimwood: The amount of work that has been done by all manufacturers on lubrication for specific jobs emphasizes the importance of lubrication in respect to wire rope life and underlines the fact that when a rope goes into service one of the major requirements from there on is field lubrication. Speaking of field lubrication, we as well as other manufacturers are quite careful of the miscibility of the original lubricant as compared to the lubricant that will be used later when the rope is in service.

The other thing I would like to mention is that

service-wise there is no doubt the field lubrication can add a considerable amount of increased life to your rope as well as to the safety of the operation in general.

A. B. Whitlock, Jr.: In the interest of more fully describing the construction and design of wire rope, mention should be made of the different core materials. Special reference should be made to fiber cores and IWRC's and the different lubrication problems of each. Fiber cores are generally prelubricated. The purpose of this is to preserve the fibers and permit the fibers to flex and move freely against each other. It should be pointed out that a fiber core does not act as a reservoir of lubricant for the rope. IWRC's are lubricated with heavy duty lubricants. The lubricant must be able to stand up against the heavy pressures between the rope strands and the strands of the IWRC. Of course, the lubricant must protect against corrosion and have sufficient lubricity to allow component parts to move freely. The core lubricants selected for either fiber core or IWRC must be compatible with the lubricant used on the rope strands.

The paper implies that until recently wire rope companies did no laboratory testing on lubricants. Field testing and actual service records are most valuable and of prime importance. However, this company has used visual and laboratory methods of testing lubricants for a long time. To say the least, the testing prevented sending wire rope lubricated with entirely unsuitable lubricants out into the field. I am sure that most wire rope companies have employed testing of this nature.

The paper states that the primary consideration in lubricant selection is high and low temperature behavior and ability to adhere to the rope. These factors are most important. However, lubricity, corrosion protection, resistance to washing, effects of exposure to the elements, etc., are also most important.

The oven test, designed to check a lubricant's ability to withstand high temperatures without dripping or flowing from the rope, is a most useful method for control. In addition, we believe dropping point tests on the lubricant in accordance with ASTM-D-566 are significant. Our mill has been able to correlate dropping point results with stranding machine lubricant pump temperatures and with dripping temperatures for ropes stocked in our warehouses.

It is our belief that the stripping tests using coated thin steel strips has merit especially when rope wire is oil coated in storage. A lubricant consistency test such as a penetrometer test, as covered by ASTM-D-217, is also of value. None of these tests demonstrate the effect of "throw off" as encountered on rotary drilling rigs. The best equipment we have observed is a centrifuge which throws lubricant from a rapidly rotating layer of rope on a drum onto a clean paper liner for subsequent weighing.

Periodic field lubrication of wire rope is so important an item in obtaining maximum safe service life that the subject should be expounded. It is true that there are numerous field dressings and numerous methods of applying these dressings to wire rope in the field. Ropes operating on various pieces of equipment and under different operating conditions have slightly different requirements with regard to field lubrication. Nevertheless, there are certain requirements common to all wire rope applications regarding proper field lubricant and method of application. The lubricant selected must have the following characteristics:

1. Compatible with the lubricant on the rope at the time of manufacture.
2. Penetrating qualities.
3. Adhesive and cohesive properties within the full range of operating temperatures.
4. Good lubricity.
5. Suitable for field application without extensive or elaborate equipment.
6. Corrosion inhibiting properties.

The method of application is dependent upon the operation and the lubricant used for field dressing. Some of the common methods are listed:

1. Hand application of a light coating of lubricant by means of saturated rag or paint brush.
2. Lubrication by immersion of rope in a specially designed lubrication trough.
3. Vapor spray method of continuous lubrication.

We heartily concur that wire rope is a machine and like any other machine must be lubricated periodically during its use to obtain maximum service.

Louis A. Stanzione: The importance of wire rope lubrication was emphasized with the example of the fatigue tests conducted on lubricated and nonlubricated aircraft cord. I feel that a test of this type might also be a valuable tool for use in the selection of a wire rope lubricant.

I would like to state that besides the methods of applying lubricants mentioned, a number of large shovel operators are using automatic lubrication systems for lubricating rope.

To correct any misunderstanding, I would like to make clear we do not consider the behavior of a wire rope lubricant under high and low temperatures and its adhesive characteristics as the only criteria in the selection of a lubricant.

We at Bethlehem Steel Co. were principally interested in these factors because there were no standard tests for checking wire rope lubricants under these conditions. On the other hand, such factors of lubricity, corrosion protection, resistance to washing, effects of exposure to the elements, etc., could be determined by such standard tests as the Shell four-ball tester, humidity cabinet test, salt spray test and accelerated weathering test. The results of such tests were furnished by the lubricant supplier when he submitted a new product and there was no need for further testing along these lines.

With regards to the stripping test we have found that not only is it important when the rope wire is treated with oil for storage purposes, but in performing this test we have found that certain cold-application, solvent, cut-back types of rust preventives have prevented the lubricant from properly adhering to the wire rope. ▲

Power Dispatching In A Steel Plant

by C. L. Eichenberg,
Assistant Superintendent
Electrical Dept.,
Bethlehem Steel Co.,
Bethlehem, Pa.

. . . . the installation of a centralized power dispatching station in plants whose generating systems are tied into the lines of the local utility will improve continuity of service . . . .

SEVENTY-FIVE years ago, electrical generation was introduced in the steel industry. The earliest use of electric power was to provide lighting in the mills, but as electric motors became available they were applied to various drives to supplement and later supplant steam, hydraulic and pneumatic drives, which up to that time were universally used.

The development of the electric motor as a prime mover for heavy equipment parallels the growth of the steel industry. Every significant increase in steel producing and finishing capacity has been preceded by the development of improved electrical equipment. Although the process of electrification of the industry was completed almost 35 years ago, the kilowatt-hours of power required to produce a ton of finished product has been steadily increasing. In the year 1947 a ton of finished steel required 268 kwhr of power. In 1957 this figure had increased to 415 kwhr per ton, and it is estimated that by 1963 the figure will have increased to 480 kwhr per ton. This expanded use of electric power has resulted in an improved product with a substantial decrease in the required number of man-hours of labor per ton. From the foregoing it can be concluded that electric power has become one of the most important requirements for the manufacture of steel. As the pressure increases to step up production rates and reduce costs through automation, electric power will become more important than ever.

The importance of uninterrupted electrical service to steel production is appreciated when one considers that practically every phase of operations is intimately connected to electrical energy. The interruption of power, even for a short period of time, can cause considerable damage to equipment and result in a severe loss of production. But, before developing a plan to insure continuity of electric power, one must consider its characteristics.

Electric power as a commodity is peculiar because it cannot be stored. Unlike water, it cannot be contained in a reservoir to guard against contingencies or to supply the peak demand. Electric power must be generated exactly in accordance with the demand, and facilities must be available to transmit it where required, as it is generated. Failure to meet these requirements will result in an impairment of service and may be the cause of a complete shutdown.

Power dispatching is the control and direction of all generating, transmitting and consuming units associated with a power system. All power systems need and utilize dispatching to some degree, but the need for centralized dispatching is dependent upon the size and character of the system. A few steel mills purchase their entire power requirements, but most integrated plants generate a portion of the power used and purchase the remainder from a local utility. This latter group is the one which can utilize centralized power dispatching most effectively.

The Bethlehem plant of the Bethlehem Steel Co. has been utilizing centralized power dispatching since 1943. Prior to that time the system dispatching was performed by one of the substation operators assisted by the foreman of power. During the period of World War II the system was expanded to provide for increased production demands, and the resulting complexity plus a need for uninterrupted operations made it desirable to establish the position of load dispatcher.

The power system at the Bethlehem plant is composed of the original 25-cycle system to

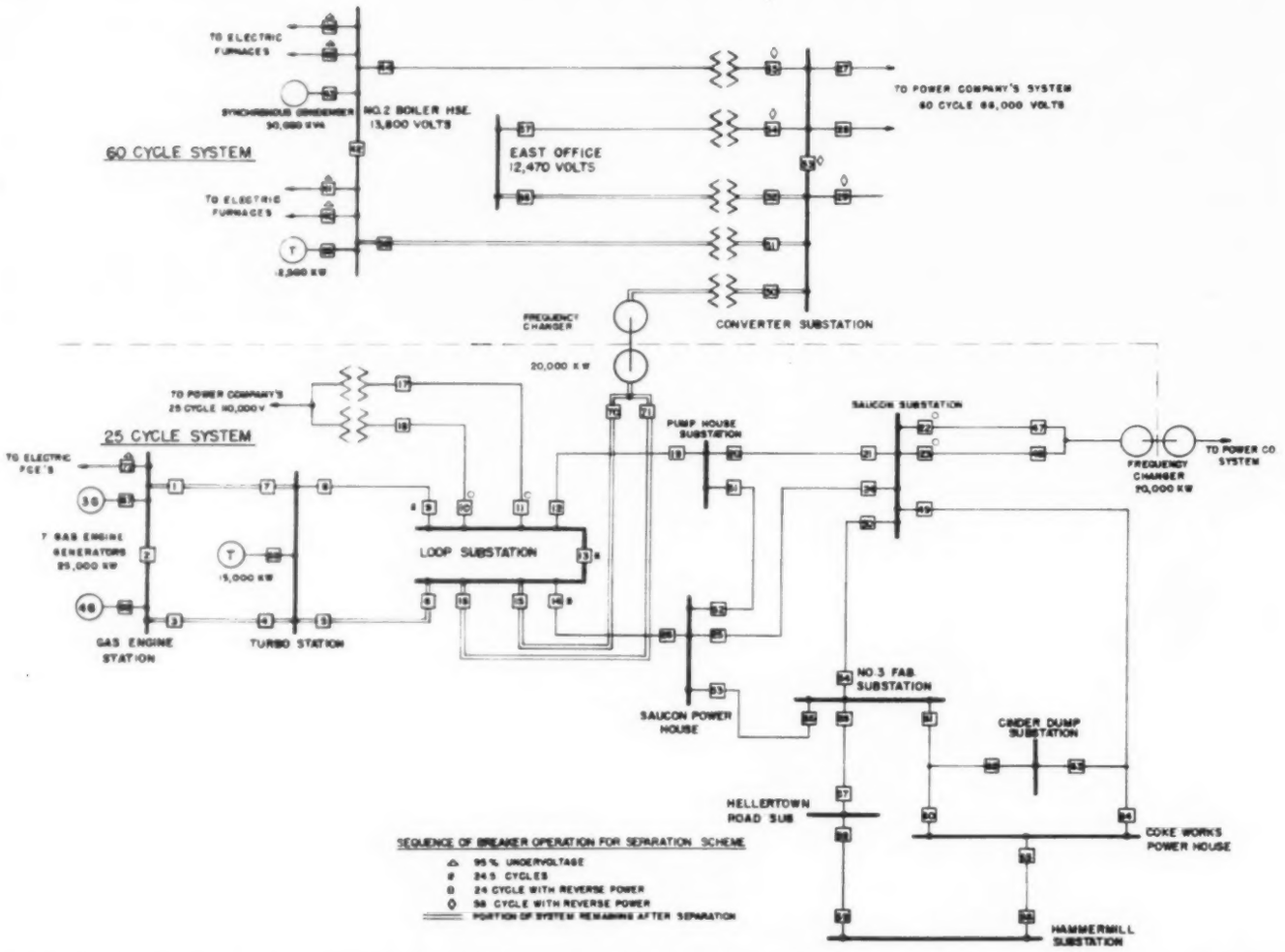


Figure 1 — The 25-cycle primary transmission system at the Bethlehem plant has as its power source seven gas engine generators totaling 25,000 kw, a 15,000-kw steam turbine, two 20,000-kw frequency changers and a 24,000-kw transformer capacity from the local utility as shown on this simplified one line diagram.

which is connected the newer 60-cycle system. It serves a completely integrated plant of 3,900,000 tons capacity which includes blast furnaces, coke ovens, open hearths, rolling mills and electric furnaces plus extensive manufacturing facilities for cast, forged and machined products. The total generation produced by the plant is 40,000 kw of 25-cycle power and 12,500 kw of 60-cycle power. The power company's capacity to the plant is 64,000 kw of 25-cycle power and 57,500 kw of 60-cycle power. Plant load at full production is in excess of 100,000 kw, and total power consumed per month exceeds 50,000,000 kwhr.

The plant power system one-line diagram shown in Figure 1 indicates the main 25-cycle system to be a loop. Generation is brought into the loop at four points; namely, seven gas engine generators at the gas engine power house, a 15,000-kw steam turbine at turbo station, a 20,000-kw frequency changer from converter substation and 24,000 kw of transformer capacity from the power company's Hauto Station both terminating at Loop Substation, and a 20,000-kw frequency converter at Freemansburg Substation. The 12,500-kw, 60-cycle generator connects to the 60-cycle system of the plant which in turn is connected to the power company's 66-kv transmission network.

The power system just described is quite flexible, but it also offers many problems in operation. The fact that it is possible to receive 25-cycle power at three different locations means that it is also possible to reverse the flow of power by bringing in energy at one point and returning it to the power company at another point. This is a condition which does not normally exist, but the unforeseen shifting of load either on the power company's or the plant's system does cause it to occur on occasions, and unusual situations sometimes make it advantageous for the power company to operate in this manner.

Load utilization of power produced by the Bethlehem system is accomplished by means of transformer substations, motor-generator sets, synchronous converters, rectifiers, and main drive motors. To the system are connected 39 transformer substations, 17 motor-generator sets, 16 synchronous converters, 2 rectifiers and 41 drive motors operating at 2300 volts and above. There are also one 7-ton, one 25-ton and four 50-ton electric furnaces connected to the system along with a 30,000-kva synchronous condenser. Operating voltages include 110,000, 66,000, 13,800, 12,470, 6900 and 2300 volts.

The load dispatcher is the designated authority to dispatch all electrical power in the Bethlehem Plant. He is located at loop substation which is geographically and electrically in the center of the system. The dispatcher's headquarters is arranged functionally and

provided with dual facilities to accommodate two dispatchers when required. Figure 2 shows the operating position of the dispatcher seated before the station duplex panel. A complete complement of instrumentation is mounted before the dispatcher, and he can see at a glance not only the loads on the lines terminating in his station, but also the telemetered indications of total plant generation, Freemansburg frequency-changer load, and total electric furnace load.

The effectiveness of a central dispatching system is dependent upon the system of communications with which it is provided. When dispatching power under emergency conditions, the proverbial "busy telephone" cannot be tolerated. The Bethlehem dispatcher's communicating system is designed to provide the most reliable and complete service that is commercially available.

The communication system centers about the private branch exchange, or PBX board, which is mounted in front of the dispatcher's desk. A duplicate PBX is mounted in front of the second dispatchers desk, thus providing duplicate facilities for 2-man operation. Each station is equipped with the conventional dial-operated telephone, which is connected through the plant exchange. A private telephone system connects the dispatcher's board with each power station, substation and remote switching point. This private system, which is installed and maintained by the telephone company, is magneto-operated but does not connect through the plant central telephone exchange. It is therefore a completely separate system, free from interference and provides a most effectual means of communication since it permits multiple conversations between the dispatcher and any given number of stations. The PBX is also equipped with a private line to the local power company's system operator and several lines direct to the city telephone exchange.

A second source of communication is provided to the dispatcher by means of a short-wave radio system. This system, which operates on the industrial frequency assigned to the plant trucks, permits communication at all times between the dispatcher and the high-tension inspector's truck. Trouble calls, which require remote switching, can be handled expeditiously

Figure 2 — The load dispatcher's headquarters is located in the Loop substation. It contains dual facilities from which the operators can see at a glance the operation of the entire power system.

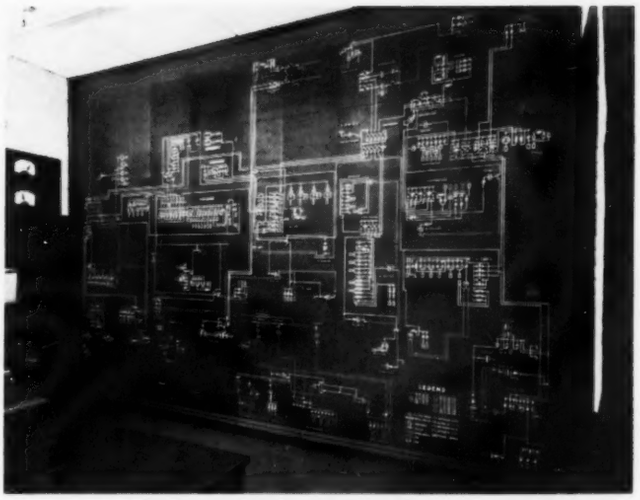


Figure 3 — The dispatcher is provided with a complete picture as to how the system is operating by this one-line schematic diagram with indicating lights.

in this manner on a 24-hr-per-day basis.

The power dispatcher's authority is exercised over all personnel employed in the Bethlehem plant's power system. Each station operator must report his presence at the beginning of each shift and the dispatcher is responsible for filling the position if a man is unable to report as scheduled. No operation is performed on the system without first securing the dispatcher's approval. This requirement includes the switching of generating units and all high and low-voltage lines. The only exceptions to this rule are the permission granted to operators to reclose d-c breakers immediately upon tripping or operation of high-voltage circuits in case of extreme emergency.

The dispatcher is responsible for keeping complete and concise records of all transactions involving the power system. A complete log is maintained on which is recorded the hourly readings of each station producing generation or receiving purchased power. These readings are transmitted hourly to the power company's system operator and the plant gas checker.

The Bethlehem plant gas checker is the designated authority to direct the operation of gas distribution and steam generation. Since all generation at Bethlehem is closely related to gas production and distribution, the gas checker determines the extent and nature of all electrical generation. The load dispatcher must closely coordinate his activities with the gas checkers in order to keep the plant power load in balance with the generation. To better enable the gas checker to visualize plant generation he is equipped with telemetered instrumentation of plant generation and power purchased as well as total electric furnace loading.

In order to keep the dispatcher acquainted with the power system connections, he is provided with an enlarged one-line diagram as shown in Figure 3. This diagram, which is revised periodically, is equipped with indicating lights to represent all major units and lines. By means of a central control board the dispatcher can indicate which apparatus and lines are in service at a given time; thus, at a glance, he has a complete picture of the system as it is operating.

One of the greatest assets to effective dispatching is the provision to record conversations. The Bethlehem

WORK REQUEST
16849 (Rev.A 9-55)
(Old AE 481)
LOAD DISPATCHER'S OFFICE

Request No. 1001

Rec'd By Livingston

Permit No. 1543

Date	6-31-58	Time	8:15 A	Location	Gas Engine Station
Requested By	Oper-Jones			For Date 6-31-58	For Period 8:45 AM to 3:15 PM
Granted By	Livingston			For Date 6-31-58	For Period 8:45 AM to 3:15 PM

Equipment Desired	#1 AC Generator
Work to be Done	repair engine
Switching Required	Open #1 AC Gen. AC B & Field Breaker & RT control Open #1 AC Gen line & Bus disconnects & move selector switch to position #3 & RT check #1 AC Gen. start air valve closed & RT.
Arrangements: For other than Station Switching	
Operation Affected	

Interruptions Prearranged	Department Affected	Name of Party Granting Inter.	Duration	Arranged By

Request Postponed By	On Date	Postponed to (Date)	Work Completed

Record on reverse side all conversation pertaining to this request.

Figure 4 — All persons desiring to work on high-voltage lines or equipment must fill out this request form and file it with the load dispatcher one day before work is to commence.

dispatcher is equipped with voice recording apparatus which is in operation at all times. Each call received, regardless of its nature, is recorded, and should questions arise pertaining to instructions given or received, a play-back always reveals the true story. This recording of conversations is very important in the application of the permit system since it provides a positive check on instructions given to all persons involved in switching lines and high-voltage apparatus in and out of service.

Figure 5 — The dispatcher studies the request, Figure 4, determines the necessary blocking, and fills out this permit.

Approx. Clearing Time 3:15 PM

PERMIT
16848 (Rev.A 9-55)
(Old AE 480)
ELECTRICAL DEPT. - LOAD DISPATCHER'S OFFICE

Permit No. 1543

Request No. 1001

Date 6-31-58 Time Issued 8:54 AM Location GAS ENGINE STATION

Issued By Livingston To oper-Jones of the AE Dept.

Permission is hereby given per To repair engine

APPLIED	DETAILS OF BLOCKING	REMOVED
8:50A	Opened # AC Gen. A.C.B. & Field Breaker & R.T. Cont.	
8:50A	Opened # AC Gen. Bus & Line Discs. & Moved Sel. Sw. To Pos. # 3 & R.T.	
8:50A	Checked # AC Gen. Air Start Valve Closed & R.T.	

Also see permit No.	Blocking Checked	
Cleared By	Time	Date
Inspected By	Time	Date
Closed By	Time	Date

Continue details of blocking on reverse side.

In order to safeguard personnel required to work on high-voltage apparatus and lines and to control the method by which switching is accomplished, the Bethlehem plant adopted a permit system under the direction of the load dispatcher. All persons who desire to work on high-voltage lines or equipment must declare their intentions to the dispatcher in the form of a request which, if possible, is filed a day in advance of the time when the work is to be performed. The request form which is shown in Figure 4 is filled out by the dispatcher with all the information pertinent to the job. The dispatcher studies the request and determines the amount and extent of the blocking necessary, and proceeds to fill out a permit as shown in Figure 5.

When the time arrives to take the requested equipment out of service, the dispatcher gives the person making the request the details of blocking. The person receiving the blocking instructions repeats them to the dispatcher as he received them, word for word, and then proceeds to apply the blocking. The blocking consists of opening the necessary breakers and disconnect switches, withdrawing draw-out breakers from the bus structure, and removing potential transformer connections or fuses. Red tags, properly filled out, are then attached to the control switches, disconnect switches or other devices blocked and are not removed until the permit is cleared. The person to whom the permit is to be issued then calls the dispatcher and relates to him the exact blocking applied and the time accomplished. The dispatcher repeats this information in order to prevent any misunderstanding and records the information on the permit. It should be understood that the person who does the switching and tagging is not necessarily the person to whom the permit is issued.

Upon receipt of information that the blocking is properly applied, the dispatcher issues the permit to the person designated to receive it and notes thereon the time of issuance and the dispatcher's name. The permit is not issued, nor can it be accepted, until the person receiving it has accepted the blocking as satisfactory to himself. The person requesting the permit has the right to question the adequacy of any or all parts of the blocking provided.

The permit when once issued can only be cleared by the person or title to whom it was issued or by a specially designated higher authority. When the work on the blocked equipment has been completed, the person holding the permit must make sure that all men working under the permit are clear and will remain clear of the equipment involved. It is also the sole responsibility of the person holding the permit to determine that all grounds and safety measures not included as a part of the blocking on the permit are removed before reporting everything clear to the dispatcher. When thus reported, the dispatcher clears the permit and records the time of clearance on the permit record.

Special arrangements are available to clear permits temporarily for the purpose of testing. Before a temporary clearance is requested, the holder of the permit must ascertain that all grounds are removed and all the men are clear of the equipment to be tested; then, upon agreement between the person who holds the permit and the dispatcher who issued it, tests can be made after removing the blocking necessary to conduct the tests. After the testing is completed, the permit can be cleared permanently or reissued to the same person who held it originally, after all the blocking has been replaced. The time of temporary clearance, the time of reissue or the time of permanent clearance is recorded on the permit by the dispatcher.

It is important to emphasize that the Bethlehem plant permit system utilizes equipment blocking and the application of red tags for the protection of personnel working on high-voltage apparatus. For the protection of equipment, when no work is to be done on it, a separate permit system is in effect in which yellow tags are used instead of red tags. These yellow tags designate the conditions under which the high-voltage lines or equipment may be placed in service, and the same procedures are used to apply and clear permits.

Education is considered a fundamental necessity for a power dispatcher. In order to insure a working knowledge of the equipment over which their jurisdiction extends, the load dispatchers at Bethlehem are provided with a comprehensive file of drawings, instruction manuals and pertinent data of all the high-voltage power apparatus in the plant. Particular emphasis is placed upon the important aspects of protective relaying and a complete reference covering the relay settings for every piece of equipment is provided for the dispatcher's use. The dispatchers are also given the opportunity to visit each power station periodically to renew their acquaintance with the physical arrangements of the various components and to participate in the training program for operators.

Dealing with unusual situations encountered in the operation of a power system is the power dispatcher's most important function. Steel mill power systems are continually expanding and becoming more complex. Likewise, the utility power systems are also growing in size and complexity. As the growth and complexity of these systems increases, the problem of handling emergencies becomes more difficult.

The consolidation of public utility generating capacity by the use of system interconnections has contributed greatly to the reliability of electrical service and the economy of operations. Through such connections it is possible to operate the most efficient generators on the network to carry the base load and the least efficient generators to carry the peak load. Variation in the time of peak load between the component systems comprising the interconnection also makes it possible for one system to carry the peak load of another system, thus minimizing the amount of reserve generation required. All these improvements, however, are dependent upon the performance of the interconnecting tie lines and the loss of one of these important lines or the loss of a key generating station can start a chain of events which may adversely affect the entire system.

The operation of a steel mill power system in parallel with a public utility system is ideal in many respects. The stability provided by the power company's system absorbs the peak loads and solves the problem of frequency regulation. Any decrease in mill generation caused by variation in by-product fuel supply is compensated for automatically by the utility system. The loss of a portion of the plant generating capacity

can generally be offset by the utility system with no ill effects. But the one situation which can adversely affect a steel mill power system is the collapse of a portion or all of the utility power system caused by the loss of generating capacity. This condition always results in the steel mill system feeding back into the utility and the two systems collapsing together.

The Bethlehem plant power system is connected to a utility which is part of the Pennsylvania New Jersey-Maryland interconnection. This interconnection has had a remarkably good performance record for many years, but there have been occurrences, particularly during ice storms and heavy snow storms, when a considerable portion of the utility system has been disabled and the plant power system jeopardized. A critical study was made of the situation with the purpose of devising a method of separating the plant from the utility system when such a condition arises in order to maintain the most vital services in the plant.

The study revealed that the first indication of trouble on either the plant or utility system is evidenced by a sharp dip in voltage, and that the prompt removal of unessential load at this time may tend to alleviate the difficulty. The most logical load to shed in the Bethlehem plant consists of five electric arc furnaces; therefore, the breakers in the power stations serving these furnaces were equipped with instantaneous undervoltage relays set to operate at 95 per cent of normal voltage. The study further indicated that when the utility company's system was in serious difficulty it was always accompanied by a decrease in system frequency and a flow of power from the plant system to the utility system. With this fact in mind, the plant system was equipped with instantaneous power directional relays coupled with under-frequency relays, applied at strategic points, to separate the plant from the utility and to preserve the most essential plant services. This method of segregation as shown in Figure 1 indicates that a dip in system frequency to 24.5 cycles results in the tripping of breakers 9, 13 and 14 followed by breakers 29, 33, 34 and 35 at a system frequency of 58 cycles accompanied by a power flow from the plant to the utility. This action isolates all of the plant generation from the utility as shown by the double lines and divides the plant system into two parts with the most essential services tied into the section containing generation. The remainder of the plant system is left connected to two power company sources with the provision that a further drop in frequency to 24 cycles accompanied by a flow of power to the utility will trip one of these sources to prevent the plant system from carrying an excessive load to satisfy the utility company demand.

The essential services preserved by this method of system segregation include the blast furnaces, a water pumping station, Corporation general offices, alloy open hearths, alloy rolling mills, and machine shop manufacturing facilities. The production units permitted to remain on the utility system include structural mills, open hearths, and coke ovens. These latter facilities are considered the most expendable and are able to withstand a total power interruption with the least number of complications.

Upon the occurrence of a system separation, the load dispatcher immediately gathers the facts related to the difficulty and proceeds to lay plans for a restoration of service. If the power company service is available, upon the direction of their system operator, the two systems are synchronized and tied together. If the utility company's service is not available the power dispatcher checks the load carried by the plant generators and if sufficient margin of capacity exists, he picks up the load previously dropped and thus proceeds to restore service in an orderly fashion.

Figure 6 — Four unattended stations are operated by supervisory control, the sending panels of which are located in the load dispatcher's office and are shown here.

The method of restoring service is closely related to the margin of generating capacity available and the importance of the consuming units. Each power station operator is provided with a priority list which he uses to determine the order in which the operating departments are re-energized, with preference given to those departments utilizing hot metal. If necessary, the least important operations are delayed until sufficient generating capacity is available to carry the load.

The use of supervisory control is of considerable importance to power dispatching. Whenever unattended stations are vital to power system operation, it is desirable to control the switching functions remotely and thus avoid delays in service. The Bethlehem plant utilizes four supervisory control systems to operate four unattended stations. One of these stations controls power to the plant's central pumping station, the second controls power in the coke plant area, and the remaining two control power to the two recent rolling mill installations. Figure 6 shows the sending panels of the supervisory control located in the load dispatcher's office.

There are many other features which can be added to a power system to assist in the problem of power dispatching. The use of automatic reclosers on many of the high-voltage transmission lines of the Bethlehem plant has been a very definite asset. The performance of these reclosers has been very gratifying, and in almost 100 per cent of the cases where a line is tripped by pilot-wire relay, the reclosure has been successful. This means much to the continuity of service and relieves the dispatcher of considerable work during lightning storms.

Much has been said about the virtues of a central system of power dispatching and the various aids to safe operation and continuity of service. Not all plants are fortunate enough to be equipped with facilities such as

those just described, but there are many features which can be adapted quite readily and others which can be provided for by long range planning. There is certainly no doubt in the minds of the power operating people of the Bethlehem plant that the load dispatcher is a very vital person to plant operations, and the fact that he is constantly on duty provides peace of mind for all supervisory personnel of the electrical department.

Discussion

PRESENTED BY

PAUL THANOS, Assistant Superintendent, Power and Steam Depts., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

C. L. EICHENBERG, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Bethlehem, Pa.

JOHN KOSTELAC, Assistant Electrical Superintendent, Crucible Steel Co. of America, Midland, Pa.

J. D. O'ROARK, Assistant Manager, Department of Service and Maintenance, Electric, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.

Paul Thanos: I do have several questions I would like to ask. The first concerns automatic reclosing. Are those installed at all voltages, or at exactly what voltages are they installed? At what time intervals do they close? Do they close instantaneous, or do they close with a time delay? How many reclosures do you have? I would also like to know if that phase of your operations has given you any trouble.

On your maintenance work on lines, do you ground your lines, and what high-tension voltage lines do you ground for the protection of people?

C. L. Eichenberg: At the present time automatic reclosers are applied to 6900-volt lines only, although it is practical to apply them to lines of any voltage. The automatic reclosers used are of the time-delay type capable of three reclosures before locking out. They are adjusted to provide one reclosure, five seconds after the line has tripped.

On all lines of 2300 volts and above, grounds are applied for the protection of personnel. The safety regulations of the electrical department require men to work between grounds, i.e., grounds are applied to opposite ends of a tie line capable of being energized from either end. The number of grounds applied is governed by the short circuit capacity of the system. On sections of the system capable of producing 50,000-ampere short circuit current, four grounds composed of 4/0 conductors are used as minimum protection.

John Kostelac: Mr. Eichenberg, assume that your system does not have any synchronous converters; would there be a necessity for such an elaborate system and would a dispatching operator be required?

C. L. Eichenberg: The use of multiple-frequency converters does complicate the problem of power dispatching to a certain degree, but the need for dispatchers is not predicated upon the complexity of the system only. The dispatcher is the directing authority for the operation of the power system and as such he relieves the general foreman of power of all the details incident to the operational phase of the business. This, in turn, permits the foreman to devote his time to problems of maintenance and the development of policy.

J. D. O'Roark: When the load is dumped or when you separate from the utility, what frequency do you separate at and how is that frequency determined?

Do you dump the load or separate your entire operation at one frequency, or do you taper the frequencies at various levels depending on the relative importance of the load or operation?

C. L. Eichenberg: A very comprehensive study was made of the performance of the Bethlehem plant power system under conditions which would require separation from the utility company's system, and based upon that study, the first separation is made when the frequency of the 25-cycle system dips to $24\frac{1}{2}$ cycles. The second step in the separation process is made when the frequency of the 60-cycle system dips to 58 cycles. In both cases, a decline in system frequency must be coupled with a reverse flow of power to the utility system in order to actuate the separation process.

J. D. O'Roark: The next question is: Do you attempt to control your demand? That is, if you have an established demand, when you show any possibility of exceeding the demand, do you cut back on any of your loads and stay within the established demand?

C. L. Eichenberg: The Bethlehem plant power system operates with a fixed one-hour demand limit which is adjusted periodically to fit the level of production. When the total number of kilowatt-hours purchased from the utility in any given hour approaches the maximum demand limit, steps are taken to reduce the load by lowering the power input to the electric furnaces or taking furnaces off the line entirely.

J. D. O'Roark: Do you use any secondary fuels? That is, if you lose your blast furnace gas or cut back on the coke gas, do you fire any coal on a short-time basis to fill in the fuel gap?

C. L. Eichenberg: The most important source of steam generation is the high pressure boiler which supplies the topping turbine. This boiler is normally fired by blast furnace gas and when the supply of gas falls below the steam requirements, the boiler automatically switches to oil as an auxiliary fuel.

J. D. O'Roark: The next question concerns the load dispatcher. Is he a salaried individual or an hourly-paid man; and if he is on an hourly basis, what job class does he command?

C. L. Eichenberg: The load dispatcher is a supervisor in the Bethlehem plant, and as such he is a salaried employee.

J. D. O'Roark: In this rather comprehensive coverage of your power system, you have some equipment, such as your supervisory control and your relays, which are in some cases rather intricate. What type of service and maintenance organization do you have to insure the reliability and proper functioning of that class and type of equipment?

C. L. Eichenberg: Relay maintenance is performed by two men, one of whom holds the title of relay tester and the second man, who holds the title of assistant relay tester. These men devote all of their time to periodic testing and maintenance of relays and control systems. ▲

Association of Iron and Steel Engineers
1959 Convention

HOTEL SHERMAN CHICAGO, ILLINOIS

SEPTEMBER 28, 29, 30, OCTOBER 1

PROGRAM

MONDAY, SEPTEMBER 28

9:00 am—REGISTRATION—
Old Chicago Room

9:15 am—BUSINESS MEETING—
Louis XVI Room

Conducted by President Emil Kern

9:30 am—ELECTRICAL SESSION—
Louis XVI Room

Chairmen: R. J. Beeswy, Superintendent, Electrical Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

John F. Kostelac, Assistant Electrical Superintendent, Midland Works, Crucible Steel Co. of America, Midland, Pa.

"Feedback Automatic Gage Control for Hot Strip Mills," by T. H. Bloodworth, Chief Systems Engineer, Electrical Application Dept., E. H. Christian, Engineer, and J. H. Stoltz, Engineer, Metal Working Section, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

"Electrical Power Demand Regulating System at Geneva Works," by W. H. Strate, General Supervisor—Electrical Engineering, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

"Electronic Maintenance Training at Allegheny Ludlum Steel Corp.," by James C. Haube, Supervisor, Training and Maintenance, Electro-Mechanisms Dept., Allegheny Ludlum Steel Corp., Brackenridge, Pa.

9:30 am—COMBUSTION SESSION—
Crystal Room

Chairmen: David Cousley, Assistant Superintendent Utilities, Steubenville Works, Wheeling Steel Corp., Steubenville, Ohio

Charles W. Dunn, Superintendent Utilities Dept., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Automatic Control Systems for Gas Mixing Stations," by J. K. Sazavsky, Chief Application Engineer, GPE Controls, Inc., Chicago, Ill.

"Expansion of Inland's No. 3 Open Hearth Shop," by Richard G. Phelps, Manager, Steel Production, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"Increased Open Hearth Production with the Use of Oxygen," by T. A. Thompson, Assistant Superintendent Open Hearth, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.

2:00 pm—OPERATING PRACTICE SESSION—
Louis XVI Room

Chairmen: H. A. Long, General Manager Operations, Pittsburgh Steel Co., Monessen, Pa.

Stephen Vajda, Staff Process Design Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Some Applications of Computer Control in the Iron and Steel Industry," by Dr. T. M. Stout, Manager, and Dr. S. M. Roberts, Process Analyst, Process Analysis Dept., The Thompson-Ramo-Wooldridge Products Co., Beverly Hills, Calif.

"Powder Lancing in Steel Mill Operations," by C. B. Milton, Project Engineer, Development Laboratory, Linde Co., Newark, N. J., and L. F. Keel, Engineering Service Representative, Linde Co., Pittsburgh, Pa.

"Economic Forecasting in the Steel Industry," by R. D. Woodward, Analyst for Commercial Research and Industrial Development, Bethlehem Steel Co., Bethlehem, Pa.

2:00 pm—MECHANICAL SESSION—
Crystal Room

Chairmen: C. H. Good, Jr., Chief Engineer—Central Operations, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

G. M. Kyle, Assistant Superintendent, Mechanical Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"Fairless Works, Sheet and Tin Division, Industrial Wastes Treatment," by William A. Sech, Technical Coordinator, Maintenance and Utilities Div., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Hard Surfacing Blast Furnace Bells, Hoppers, Etc.," by Roger Fluck, Assistant Superintendent, Weldment Dept., and Charles W. Dunn, Welding Supervisor, Bethlehem Steel Co., Bethlehem, Pa.

"Automatic and Programmed System for Assembling and Charging Blast Furnace Raw Materials," by John F. Meissner, President, Meissner Engineers Inc., Chicago, Ill.

TUESDAY, SEPTEMBER 29

9:00 am—ELECTRICAL SESSION—
Louis XVI Room

Chairmen: H. W. Dorset, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

R. G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

"Continuous Annealing Line Drive Systems," by Richard M. Bosshardt, Application Engineer, Reliance Electric & Engineering Co., Cleveland, Ohio

"The Application of the Mercury Arc Rectifier to Large Reversing Mill Drives," by M. B. Antrim, Manager, Engineering-Construction, Lukens Steel Co., Coatesville, Pa.

"Performance Characteristics of a Rectifier Powered Plate Mill," by C. E. Rettig, Manager, Rectifier Circuit Development, General Electric Co., Philadelphia, Pa., and J. E. Peebles, Steel Mill Application Engineer, Metal Rolling & Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

9:00 am—COMBUSTION SESSION—
Crystal Room

Chairmen: W. M. Bloom, Senior Engineer—Fuel, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

F. C. McGough, Superintendent, Fuel and Power, The Youngstown Sheet and Tube Co., East Chicago, Ind.

"Basic Refractories—1959," by Mervin A. Fay, Manager, Basic Sales, General Refractories Co., Philadelphia, Pa.

"Basic Roof Experience at Fairless Works," by Howard A. Parker, Division Superintendent, Steel Production, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Technology of Basic Brick," by George R. Eusner, Division Chief—Refractory and Mineral Technology Div., Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

2:00 pm—OPERATING PRACTICE SESSION—
Louis XVI Room

Chairmen: C. W. Bruce, Chief Engineer, Steel Plants, Republic Steel Corp., Cleveland, Ohio

H. L. Jenter, Vice President—Operations, American Steel & Wire Div., United States Steel Corp., Cleveland, Ohio

"The Evolution of the Iron and Steel Industry in South Africa," by Dr. C. M. Krüger, General Manager, South African Iron and Steel Industrial Corp., Ltd. Pretoria, South Africa

"Some Comparisons Between German and American Steelmaking Practices," by Director Dr.-Ing. Erich Kemna, Vice President, DEMAG Aktiengesellschaft, Duisburg, Germany

"Problems in Engineering the 1955–1958 Inland Steel Co. Expansion Program," by Irwin Rosenak, Chief Engineer, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

2:00 pm—LUBRICATION SESSION—
Crystal Room

Chairmen: Charles Bailey, Lubrication Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

T. A. Bessent, Lubrication Engineer, Bethlehem Steel Co., Sparrows Point, Md.

"Spray Lubrication of Roll Necks," by Alfred A. Paul, Manager, Engineering—Sales, The Brooks Oil Co., Cleveland, Ohio, and G. C. Almasi, Materials and Standards Engineering, Crucible Steel Co. of America, Midland, Pa.

"The Selection and Use of a Water Soluble Rolling Oil," by Paul W. Coffman, Assistant General Superintendent, Riverdale Plant, Acme Steel Co., Chicago, Ill.

"Lubrication of Republic's 45-In. Slab Mill," by Walter J. Rodenberger, Lubrication Engineer, Cleveland District, Republic Steel Corp., Cleveland, Ohio

6:00 pm—OLD TIMERS DINNER—
Crystal Room

WEDNESDAY, SEPTEMBER 30

9:00 am—ELECTRICAL SESSION—
Louis XVI Room

Chairmen: J. A. Drgon, Division Superintendent, Maintenance & Utilities, Edgar Thomson Works, United States Steel Corp., Braddock, Pa.

Clayton L. Squier, Assistant Electrical Superintendent, Bethlehem Steel Co., Lackawanna, N. Y.

"The Blooming Mill Programmed!" by H. G. Frostick, General Supervisor, Design Engineering, New Mills Construction, South Works, United States Steel Corp., Chicago, Ill.; J. Raymond Erbe, Metal Working Section, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.; and Marshall Brittain, Manager, Co-ordinated Digital Development, Systems Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.

"Inland's New Automatic Slabber," by R. J. Beeswy, Superintendent, Electrical Dept., and E. R. McGaughey, Superintendent, No. 3 Blooming & No. 4 Slabbing Mills, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"Is the Fault Always Electrical?" by R. J. Byrnes, Senior Electrical Engineer, Cutler-Hammer Inc., Milwaukee, Wis.

9:00 am—LUBRICATION SESSION—
Crystal Room

Chairmen: Norman A. Bracht, Lubrication Engineer, Alan Wood Steel Co., Conshohocken, Pa.

C. T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio

"Design Data for Bearings of Nylon, Acetal, and TFE Fluorocarbon Resins," by L. H. Gillespie, Applications Technologist, and G. S. Hudson, Sales Technologist, Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

"Making Lubrication More Effective as a Weapon in Management's War on Wear," by Wayne G. Ritter, President, Ritter Engineering Co., Pittsburgh, Pa.

"Filtration in the Iron and Steel Industry," by John R. McCoy, Manager, Technical Service, Indiana Commercial Filters Corp., Lebanon, Ind.

2:00 pm—OPERATING PRACTICE SESSION—
Louis XVI Room

Chairmen: William O. Bishop, Superintendent Plant No. 2 Blast Furnaces, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

Clyde A. Roberts, Jr., Chief Engineer, Structural Div., Phoenix Steel Corp., Phoenixville, Pa.

"Blowing Methods in Steelmaking," by G. M. Yocom, Assistant to General Manager, and L. Xidis, Steubenville Works, Wheeling Steel Corp., Steubenville, Ohio

"Filtering Air for Steel Mills," by C. D. Wright, Steel Mill Application Specialist, Air Filter Div., American Air Filter Co. Inc., Louisville, Ky.

"Experience in Cleaning Blast Furnace Gas with the Orifice Washer," by G. E. Reid, Utility Engineer, Steam Efficiency & Combustion Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

2:00 pm—ROLLING MILL SESSION—
Crystal Room

Chairmen: D. C. Horsman, Plant Superintendent, Continental Steel Corp., Kokomo, Ind.

R. P. Schuler, Manager, North Mills, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"Material and Design Defects in Forged Steel Rolls," by A. A. Bradd, Coordinator of Rolls, Midvale-Heppenstall Co., Nicetown, Philadelphia, Pa.

"Sandwich Rolling," by H. S. Orr, Project Development Engineer, Rolling Mills, United States Steel Corp., Pittsburgh, Pa., and Frank R. Romeo, General Foreman, Sheet and Stainless, Homestead District Works, United States Steel Corp., Munhall, Pa.

"Salient Features of Armco's New Hot Strip Mill, Butler Works," by Cyril H. Roberts, Supervising Mechanical Engineer, and Thomas M. Kilgo, Senior Electrical Engineer, Butler Works, Armco Steel Corp., Butler, Pa.

7:00 pm—FORMAL DINNER—Ball Room

10:00 pm—DANCE—Ball Room

THURSDAY, OCTOBER 1

8:30 am—INSPECTION TRIP—

To Indiana Harbor Works, Inland Steel Co., East Chicago, Ind. Buses for the Inspection Trip will leave from the Hotel Sherman.

Trip will cover important facilities of the plant, particularly those installed since the War. Trip is restricted to citizens of the United States and Canada. No ladies are permitted.

A limit of 500 is set for the trip. Priority on tickets will be given in the order that ticket applications are received. Checks must accompany trip reservations.

LADIES PROGRAM

Ladies Headquarters and Registration—
Parlor L Hotel Sherman

Monday, September 28....Coffee—9 am to 12 m
Parlor L
Hotel Sherman

Tea—3 pm
Yacht Club

Tuesday, September 29....Luncheon 12:30 pm
The Kungsholm

Honorary Chairwoman: Mrs. Emil Kern

Honorary Vice Chairwoman: Mrs. E. O. Krueger

General Chairwoman: Mrs. F. H. Gill

Assistant General Chairwoman: Mrs. R. E. DuBois

To partially cover costs, a flat registration charge of $5.00 will be made which will cover all ladies activities except the formal dinner on Wednesday evening. This must be paid on registering, when tickets will be issued for these events.

AISE Annual Convention will be held regardless of steel strike status. In the event the strike is on, the inspection trip through Inland Steel Co. will be cancelled. If the strike is settled and the plants are just starting up at the time of the Convention, status of trip will be announced at the convention.

Convention Chairmen

R. J. BEESWY

J. F. KOSTELAC

DAVID COUSLEY

C. W. DUNN

H. A. LONG

STEPHEN VAJDA

C. H. GOOD, JR.

G. M. KYLE

H. W. DORSET

R. G. NOLAN

W. M. BLOOM

F. C. McGOUGH

C. W. BRUCE

H. L. JENTER

CHARLES BAILEY

T. A. BESSENT

J. A. DRGON

C. L. SQUIER

NORMAN A. BRACHT

CHARLES T. LEWIS

WILLIAM O. BISHOP

C. A. ROBERTS, JR.

D. C. HORSMAN

R. P. SCHULER

Abstracts of Technical Papers

to be

presented at technical sessions of

AISE ANNUAL CONVENTION

September 28, 29, 30, October 1, 1959

HOTEL SHERMAN **CHICAGO, ILL.**

"FEEDBACK AUTOMATIC GAGE CONTROL FOR HOT STRIP MILLS"

by T. H. BLOODWORTH, Chief Systems Engineer, Electrical Application Dept., E. H. CHRISTIAN, Engineer, and J. H. STOLTZ, Engineer, Metal Working Section, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

T. H. BLOODWORTH

E. H. CHRISTIAN

J. H. STOLTZ

△ THIS paper reviews briefly the advantages and disadvantages of two types of automatic gage control—the feedback or "absolute" system, and the gage meter or "nonabsolute" system. The gage meter system, by taking the control signal from a load cell installed in the mill stand, minimizes off-gage material due to transport time-lag. This system, however, does not recognize factors such as variations in mill roll temperatures—resulting in decreasing the roll gap when it should be increased—and in roll wear. Some method of recalibration is necessary for satisfactory operation. The feedback system, taking the control signal from a measurement of strip thickness, compensates automatically for any temperature variations or roll wear. The strip thickness measuring device must be mounted remotely from the roll bite, so compensation for transport time-lag is necessary. However, extensive testing on several hot mills shows thickness variations to be ramp functions, so that effects of transport time-lag are small.

Thorough evaluation of all facets of the two systems resulted in the selection of the feedback or absolute system. Computer studies and extensive manual simulation of proposed automatic features on a hot strip mill showed the necessity of multiple stand manipulation for maximum benefits.

The installation described embodies digital type screw positioning regulators on all five stands, a tension measuring and controlling looper between each stand and proportional control from two x-ray gages. There are no speed regulators as such, the positioning tensioning regulators being used to actuate high-speed regulating systems in the motor fields.

"ELECTRICAL POWER DEMAND REGULATING SYSTEM AT GENEVA WORKS"

by W. H. STRATE, General Supervisor—Electrical Engineering, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

W. H. STRATE

△ WHEN the Geneva plant of Columbia-Geneva Steel Division, United States Steel Corp., was constructed in 1942–43, a 50,000-kw, 0.8-power factor, 13.8-kv, 60-cycle turbogenerator was provided. This generator supplied all of the electrical energy used in the plant. The Geneva plant electrical system included a 40,000-kva, 138/13.8-kv substation connected to the public utilities high-voltage transmission lines. The contract with the public utility was an interchange agreement whereby total electrical energy "in" and total electrical energy "out" was balanced over a period of time.

The expansion of existing facilities and the addition of new facilities in 1956–57 requiring large amounts of electrical power increased the power peaks in excess of the Geneva generator capacity. A new contract agree-

ment between Geneva and the public utility was executed in 1956 to cover the new conditions. The contract included clauses covering 15-min demand, energy and a minimum bill.

To control 15-min demand power peaks and thus obtain maximum energy for the minimum bill, the Geneva plant has been equipped with a computing-type demand-limiting system. The computer displays the optimum use of energy from the public utility, and also indicates the amount of reduced operating rate of the Geneva plant and hot-strip mill required for control of demand.

This paper describes the basis on which the computer operates, the equipment used in the computer, and the installation of the equipment.

"ELECTRONIC MAINTENANCE TRAINING AT ALLEGHENY LUDLUM STEEL CORP."

by JAMES C. HAUBE, Supervisor, Training and Maintenance, Electro-Mechanisms Dept., Allegheny Ludlum Steel Corp., Brackenridge, Pa.

J. C. HAUBE

△MAINTENANCE training programs geared to the maintenance of electronic equipment existing at Allegheny Ludlum in 1954 were soon found inadequate for the rapidly developing fields of measurement, automatic control and data logging. Close co-operation of those concerned with the development and maintenance of this equipment with training personnel produced plans for the organization and training of an electronic maintenance group.

A survey of existing training sources revealed that the techniques required by these new fields were not offered in a form suitable to our needs. It became necessary, therefore, to organize a training program tailored especially for these techniques. Suitable lecture-demonstration and laboratory training equipment was obtained and available text material selected and assembled.

As the need for the maintenance organization was immediate, men with previous experience or training in electronics were tested for achievement, aptitude, interest and ability in the field. Six were chosen for the initial training program to begin immediately. Five of the six enjoyed electronics as a hobby and one serviced radios and television sets as a sideline. Two had some previous electronic training. The positions previously held by the men varied from repair helper to journeyman machinist.

This initial program consisted of training in mathematics, basic electricity and basic electronics. On-the-job training programs are set up for specific pieces of equipment as the men's backgrounds developed. Training in digital techniques, computer fundamentals, solid state electronics and control system fundamentals is being prepared for near future training.

A foreman was chosen from the group and a well-equipped maintenance shop set up.

As the number of equipment installations increased, it became necessary to increase the size of the maintenance group. In the Brackenridge Works, using the test results of the first group as criterion, four men have been chosen for a four-year apprenticeship program.

Equipment installations and local training practices in other plants of the corporation will dictate the need of a corporation-wide electronic training program. Plans are now being made to tailor such a program.

"AUTOMATIC CONTROL SYSTEMS FOR GAS MIXING STATIONS"

by J. K. SAZAVSKY, Chief Application Engineer, GPE Controls, Inc., Chicago, Ill.

J. K. SAZAVSKY

△ THE purpose of gas mixing stations is to provide a gaseous fuel that is used either as a stand-by fuel or as a universal fuel. The performance requirements and complexity of the gas mixing stations and the associated controls have increased over the years, and the number of offered types of gas mixing station control systems have increased with it hand in hand. The result is consequently, today the user has an opportunity to choose from a variety of field tested control systems.

Control systems have been designed to provide mixed gas with uniform heating value per cubic foot, uniform specific gravity, uniform combustion air requirement or uniform flame characteristics. If proper fuels are available in unlimited quantity, two, three or all four of these characteristics can be satisfied.

The problem today is not how to design the control system for the job, but to choose the proper one from those available. Operating conditions, availability of fuels, production problems, quality of product, burning equipment, design of furnaces, etc., are the criteria that influence the proper selection.

The best results can be accomplished by close co-operation between the user who can and should accurately define the problems and requirements of the gas mixing station, and the control system manufacturer or designer, who, from experience can offer optimum solutions for the given installation.

Gas mixing stations and the associated controls designed under these conditions cannot fail to give full satisfaction to both the supplier and the user.

"EXPANSION OF INLAND'S NO. 3 OPEN HEARTH SHOP"

by RICHARD G. PHELPS, Manager, Steel Production, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

R. G. PHELPS

△ AFTER three years of operation it was decided to expand Inland's No. 3 open hearth shop from four furnaces to seven. The decision to build open hearths rather than pneumatic process equipment was primarily governed by the available supply of blast furnace hot metal. No. 3 open hearth had consistently operated on a 40 per cent hot

metal charge and was an efficient scrap consumer.

The enlargement of a modern open hearth shop presented unique possibilities for improvement of furnaces and material handling equipment on the basis of actual operating experience. It was possible to make studies and changes of operating equipment rather than rely on theoretical design techniques.

Furnaces were enlarged for 320-ton heats with a maximum firing rate of 180,000,000 Btu's an hour. A completely revamped double pass checker and tunnel system was utilized to accommodate the increased gas volume. Extended hearths with single uptakes were installed to give maximum hearth area.

The paper discusses the general design and features of the expanded open hearth shop. Particular attention is paid to the changes made in furnace construction. Operating results demonstrate the advantages gained by the redesign of the equipment. Current experiments with further improvements are also described.

"INCREASED OPEN HEARTH PRODUCTION WITH THE USE OF OXYGEN"

by T. A. THOMPSON, Assistant Superintendent Open Hearth, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.

T. A. THOMPSON

△ THIS paper discusses the basic problems encountered, the steps taken to overcome these problems, and a question or two which are still being probed concerning the use of oxygen for increasing open hearth production.

Weirton has at present half the furnaces in its fourteen-furnace shop equipped with roof lances. These furnaces vary in capacity from 275 to 600 tons and show an interesting progressiveness from "temperature" to "oxygen" production. This point was impressively shown in an experimental heat which produced well over 100 tons per hour.

"SOME APPLICATIONS OF COMPUTER CONTROL IN THE IRON AND STEEL INDUSTRY"

by DR. T. M. STOUT, Manager, and DR. S. M. ROBERTS, Process Analyst, Process Analysis Dept., The Thompson-Ramo-Wooldridge Products Co., Beverly Hills, Calif.

DR. T. M. STOUT

△ THE digital control computer can be a useful supplement to conventional instrumentation in processes characterized by frequent disturbances, complex relationships between variables and conflicting objectives. Because of its cost, however, the digital control computer will be used only on large-scale processes where modest improvements in operation will justify the investment. The iron and steel industry appears to have a number of processes meeting these requirements.

Control computers can be used in a number of ways, ranging from open-loop sequence control to closed-loop optimization involving process measurements and a complex program of calculations. In the latter approach, instruments must be available for making the necessary measurements, and equations must be developed by means of which process performance can be predicted under changing conditions. These requirements present some difficulties but solutions are possible for a great many processes.

To illustrate these points, this paper discusses a number of possible computer applications in the iron and steel industry.

"POWDER LANCING IN STEEL MILL OPERATIONS"

by C. B. MILTON, Project Engineer, Development Laboratory, Linde Co., Newark, N. J., and L. F. KEEL, Engineering Service Representative, Linde Co., Pittsburgh, Pa.

C. B. MILTON

△ OXYGEN lancing is well known in the steel industry. Its use for furnace tapping, as an example, has been normal practice for more than 25 years. Powder lancing, in contrast, is relatively new. Consequently, it is not widely known despite its many advantages by comparison to oxygen lancing—particularly in the piercing or cutting of concrete and similar materials.

Oxygen and powder lancing are similar in one key aspect: With both, oxygen is passed through lance pipe. However, oxygen lancing derives its heat from the reaction of the oxygen with the consumable pipe and material being cut. It thus differs from powder lancing in two respects. First, in powder lancing a much greater quantity of heat is generated from the reaction of oxygen and powder materials introduced at the lance outlet. Second, the powder lance readily cuts or pierces nonoxidizing materials such as fire brick, slag and concrete.

L. F. KEEL

Powder lancing stems from powder cutting as developed toward the end of World War II for application to stainless steel and nonferrous metals such as copper and nickel. Like powder cutting, powder lancing utilizes metallic powders supplied from a dispenser. Although development has emphasized the piercing and cutting of concrete, powder lancing has been applied to many steel mill operations. Based on the results of extensive field tests and data obtained pertaining to accepted applications, these include the following as examples:

1. Open-hearth furnaces—ladle skulling, slag flush hole cleanout, skulling hot metal mixer lips, lancing the lip of slag runners, furnace spill removal and piercing slag pocket shot holes.
2. Blast furnaces—salamander removal prior to furnace rebuild.

3. General maintenance or structural changes in concrete foundations.

Numerous examples indicate that powder lancing has many advantages by comparison to blasting, balling and jack hammers. For some applications, however, a combination of powder lancing and some other method will give best results while, for other applications, powder lancing may sometimes be the only readily available method for accomplishing the desired end results.

Powder lancing is a valuable tool in steel mill operations. Its use should do much to reduce downtime and to increase maintenance effectiveness.

This paper presents details concerning all developments outlined here. Examples along with operating data are cited, and necessary equipment and operating requirements are discussed against the background of actual mill practice. Comparative analyses are presented in the form of available applications.

"ECONOMIC FORECASTING IN THE STEEL INDUSTRY"

by R. D. WOODWARD, Analyst for Commercial Research and Industrial Development, Bethlehem Steel Co., Bethlehem, Pa.

R. D. WOODWARD

△ THIS paper describes what economic forecasting is and also what economic forecasting is not. It tells when economic forecasting is worthwhile and the basis which is used to determine whether such forecasting will justify effort. The tools and techniques of economic forecasting in the steel industry are enumerated.

Economic forecasting must be tied in with other business procedures such as market research, operations research and so forth.

The prevalence and responsibility of economic forecasting in the steel industry are covered and the areas of application. Forecasting for steel includes the growth of the steel market by consuming industries, products and regions and these will vary with particular countries. Some estimates are made on the reliability of economic forecasting as well as future of economic forecasting in the steel industry.

"HARD SURFACING BLAST FURNACE BELLS, HOPPERS, ETC."

by ROGER FLUCK, Assistant Superintendent, Weldment Dept., and CHARLES W. DUNN, Welding Supervisor, Bethlehem Steel Co., Bethlehem, Pa.

ROGER FLUCK

△ THIS paper describes the recent program established for the hard surfacing of blast furnace bells and hoppers by automatic submerged arc welding. It also covers some of the work done during the past ten years and suggests future developments to be attained. Illustrations showing the various welding and machining operations are incorporated with the paper.

The basic reason for this program is to improve the life of bells and hoppers possibly to last a full campaign. Furthermore, the use of higher top pressures in the furnaces make it mandatory to have a more lasting seal between the bell and hopper. A thorough study has been made of all operations connected with the manufacture of cast steel bells and hoppers.

C. W. DUNN

First of all, suitable analyses of steel must be used in the pouring of the steel castings. Foundry practices were reviewed in order to provide good sound metal for the welding surfaces. Rough machining of the undercut areas was properly planned so that the finish weld deposit would have a minimum thickness.

Suitable equipment to handle all sizes of bells and hoppers required a considerable amount of engineering. A large welding positioner capable of handling 350,000 lb was purchased, as well as a welding manipulator for positioning operators, controls, automatic welding heads, etc. Gas lines with ample volume supply were installed to feed the preheat burners.

The welding procedure included the choice of suitable electrodes and fluxes, welding speeds, voltage and currents, preheat temperatures and subsequent heat treatment.

After welding and heat treatment the bells and hoppers required machining of the seating surfaces. This involved the development of proper tools, feeds and speeds on a 25 ft boring mill. A special tool was also developed to work-harden the finished machined seating surface.

Although many problems were encountered in the development of hard surfacing bells and hoppers, probably the most critical one was distortion. Minimizing distortion guarantees the most economical means of emerging with a good finished product.

At the present time, very little can be said relative to the success of this program. Only service life and improved blast furnace operation can prove the merits of hard surfacing bells and hoppers. Different welding electrodes, processes, and techniques must be tried to prove the ultimate.

"AUTOMATIC AND PROGRAMMED SYSTEM FOR ASSEMBLING AND CHARGING BLAST FURNACE RAW MATERIALS"

by JOHN F. MEISSNER, President, Meissner Engineers Inc., Chicago, Ill.

J. F. MEISSNER

△ THIS paper is intended to deal with a recently developed and highly perfected automatically controlled system, which will mechanically assemble all blast furnace raw materials. The composition of the charges, with respect to the kind and the number of materials, the stock bin location from which these must be withdrawn, the order or sequence of the skip charges are

fully programmed and these programmed functions are then carried out automatically, continuously and uninterruptedly. Advisable and necessary changes, which may be required, can quickly be instituted after which the continuous automatic operation is resumed.

The quantities of every material that individually or in combination with other materials enters into the composition of the skip charges, is determined by weight, the weights also programmed, and the charging of all metallic and flux materials, as well as coke, and the controlled operation of the skip hoist, the distributor, small and large bells, and the stock line probes will now all become part of a fully coordinated and completely programmed operation.

The programmer will automatically record all weights, classified as to the kinds of materials, and record all furnace operations with respect to time and other pertinent data and will supply a printed record for the operator.

Improved blast furnace performance and the greater production of hot metal are expected to result from the use of this system.

"CONTINUOUS ANNEALING LINE DRIVE SYSTEMS"

by RICHARD M. BOSSHARDT, Application Engineer, Reliance Electric & Engineering Co., Cleveland, Ohio

R. M. BOSSHARDT

△ AS the art of high-speed, continuous strip annealing evolves, it is worthwhile to examine the most recent installations in order to benefit from the latest technical advances.

The drive systems employed on three recently constructed continuous annealing lines are highlighted. The lines are concurrently being installed for the U. S. Steel Corp. at the Gary Sheet and Tin Mill in Gary, Ind., at the Columbia-Geneva Division in Pittsburgh, Calif.; and at the Tennessee Coal and Iron Division in Fairfield, Ala.

Designed to duplicate the other two, each line is capable of continuously annealing strip steel, cold reduced to thicknesses from 0.0070 to 0.0150 ins., and widths from 22 to 38 in. Each line has a maximum capacity speed of 1500 fpm, with overspeed in the entry and delivery sections of 1875 fpm.

Features of primary interest are the automated strip feed-up in the entry section; the arrangement of the drive system and the control of tension in the furnace section; load-sharing of bridle drive motors; the regulating system of rewind reels; and the position control of the looping towers.

"THE APPLICATION OF THE MERCURY ARC RECTIFIER TO LARGE REVERSING MILL DRIVES"

by M. B. ANTRIM, Manager, Engineering—Construction, Lukens Steel Co., Coatesville, Pa.

△ AS is well known, there are three types of mercury arc rectifiers applied to large reversing mill drives. Of these three—rectifiers with mechanical reversing switch, rectifiers with motor field reversal and rectifiers with back-to-back connections—this paper is concerned with the back-to-back type connected rectifier.

M. B. ANTRIM

Of the other two types, of which there are a great many in operation in Europe, the first has an inherent high maintenance device which becomes larger and larger as the mill horsepower increases, namely, the mechanical reversing switch. The second of these types of rectifiers, that with motor field reversal, has an inherent high reversing time due to the difficulty of speed of field reversal in large main drive motors. The back-to-back connected rectifier is a static device with inherent high speed of reversal and high overload capacity. Its efficiency, effect on the utility power system, flexibility of installation and maintenance costs are discussed. A first cost, plus operating costs, report is presented.

In addition, a planned approach to trouble shooting and also the effect of the rectifier on standard design main rolling mill motors are covered. Pictures and diagrams of Lukens' installation are shown.

"PERFORMANCE CHARACTERISTICS OF A RECTIFIER POWERED PLATE MILL"

by C. E. RETTIG, Manager, Rectifier Circuit Development, General Electric Co., Philadelphia, Pa., and J. E. Peebles, Steel Mill Application Engineer, Metal Rolling & Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

C. E. RETTIG

△ THE Nation's first major reversing hot mill powered by an ignitron mercury arc rectifier is in production. This installation represents the results of many hours of design work and development testing. Much valuable knowledge and data have been obtained from this effort as well as from evaluation of the drive during start-up and operation. The paper presents some of this knowledge and data of general interest to the industry.

The electrical equipment of this specific mill is described briefly. Operating principles and performance characteristics of a reversing rectifier drive are discussed. Some actual performance results are included. The method of reversal used and type of protection required are covered.

J. E. PEEBLES

The future of the reversing rectifier is reviewed and the types of loads a reversing rectifier can best supply are discussed.

The use of a reversing rectifier power supply for this mill indicates the degree to which mercury arc rectifiers have been applied and accepted in this country. A

review of the installation along with some of the sign posts pointing to the future can be very helpful to engineers in the steel industry considering electrical equipment for new or modernized mills.

"BASIC REFRACTORIES—1959"

by MERVIN A. FAY, Manager, Basic Sales, General Refractories Co., Philadelphia, Pa.

M. A. FAY

△ THE history of the development of basic refractories, both here and abroad, is reviewed, particularly with regard to the use of such brick in open hearth furnaces. The recent, rapid increase of all-basic open hearth furnaces is emphasized.

The construction requirements of basic refractories are discussed in the light of recent developments in basic refractory usage. This discussion covers basic refractories for open hearth roofs, front walls, back walls, bottoms, ends and regenerators and includes comments on the needs of each furnace section as to the type of refractory which is most suitable.

Various construction techniques for basic refractories are described with comment on their advantages and deficiencies.

A discussion of the economy of the use of basic refractories is presented with special attention being given the all-basic furnace.

A summary of the future outlook for basic refractories is presented with discussion of raw materials supplies, as well as probable requirements for them.

"BASIC ROOF EXPERIENCE AT FAIRLESS WORKS"

by HOWARD A. PARKER, Division Superintendent, Steel Production, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

HOWARD PARKER

△ BASIC main roofs have replaced the silica roofs at Fairless Works of United States Steel Corp. The design and type of basic roofs which are presently used cost less per ton of ingots than silica roofs. Production rates have improved because of less furnace outage time and reduced hot patching time.

The roof is constructed with radial steel plates between every third brick ring in order to suspend the brick and to give rigidity to the roof arch. Steel beams are placed lengthwise on the roof in order to hold the roof down rigidly. This construction minimizes hot face brick growth which minimizes brick peeling in service. Basic roofs of this design are averaging over 400 heats per campaign.

"THE EVOLUTION OF THE IRON AND STEEL INDUSTRY IN SOUTH AFRICA"

by DR. C. M. KRÜGER, General Manager, South African Iron and Steel Industrial Corp., Ltd., Pretoria, South Africa

DR. C. M. KRÜGER

△ THE Union of South Africa is relatively well endowed with base and precious minerals. As the world's prime producer of gold, industrial enterprise has up to fairly recently largely centered around mining activity and the development of secondary industry was relatively slow. The large deposits of coal and high grade iron ores were naturally attractive to early enthusiasts to establish an iron and steel industry, but the over-all volume and diversity of demand was such that only in the late 1920's did such a venture show economic possibilities.

Cor. Delfos' persistent efforts toward the establishment of an integrated iron and steel industry based on the country's own ores, culminated in Parliament's acceptance of the act which created the South African Iron and Steel Industrial Corp., Ltd. (ISCOR) in 1928. The aim of this act was to create a mixed or semistate industry in which government control would be accompanied by the widest public participation. The Board of directors would be fully responsible for the affairs of the corporation and neither the board nor the employees were to be members of the public service.

Iscor is therefore a state sponsored organization, in the sense that the government has large sums of money invested in it, but it is for all practical purposes organized and run, and pays the same State taxes, as an independent public corporation. The State receives a dividend approximately equal to the cost to the State of the funds invested in the corporation. This policy has enabled the corporation to keep steel prices down and to reinvest an appreciable part of its earnings in expansion. After 25 years the corporation can today meet two-thirds of the Union's steel requirements from its two completely integrated works at Pretoria (steel sections and wire products) and Vanderbijlpark (plates and strip products). With an authorized and issued share capital of £25,000,000, Iscor's assets at original cost value amount at present to more than £134,000,000 and it is at present embarked on a further expansion program of over £56,000,000.

"PROBLEMS IN ENGINEERING THE 1955–1958 INLAND STEEL CO. EXPANSION PROGRAM"

by IRWIN ROSENAK, Chief Engineer, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

△ THE Inland Steel Co. 1955–58 expansion program provided for approximately 40,000 tons per month of additional cold rolled product with space for future expansion to the capacity of two cold roll tandem mills. In addition to the usual problems which are encountered in engineering any large project, there were several

IRWIN ROSENAK

special problems specific to this particular program.

Investigation was made into oxygen process for steelmaking facilities and continuous casting for slab supply. The final decision was to provide additional pig iron by improvements to existing blast furnaces, provide three new open hearth furnaces in an existing shop, provide a new universal slabbing mill and a new cold strip mill.

A study was made of the most economical building design resulting in a majority of new buildings with 120-ft crane span. Coils are conveyed to the new cold mill by underground conveyor, and material flow in the cold mill is principally by floor level coil conveyors, without the use of ram or fork tractors.

The location of the new facilities was in question up to the time of construction and had to be designed to fit alternate locations. Location finally selected was adjacent to the hot strip mills in Lake Michigan in about 25 ft of water. Approximately 130 acres of new land was created. After fill was placed to above water level, building and machinery piers were poured without excavation. Extremely poor subsoil conditions required a considerable portion of the machinery to be piled. Special section 12 x 12-in. "H" beam piling was used throughout.

This expansion program required all new utilities, including a clean water sewer, dirty water sewer, sanitary sewer and acid sewer. In this program, Inland, for the first time, made provisions to take power from a public utility and necessary ties between the public utility 60-cycle system and the existing plant 25-cycle self-generated system were built.

This plant expansion was constructed in the scheduled time, with cost very close to the authorized amount and has met all of its production requirements.

"SPRAY LUBRICATION IN ROLL NECKS"

by ALFRED A. PAUL, Manager, Engineering—Sales, The Brooks Oil Co., Cleveland, Ohio, and G. C. ALMASI, Materials and Standards Engineering, Crucible Steel Co. of America, Midland, Pa.

G. C. ALMASI

△PROPER application of lubricant to roll necks has been an important factor in reducing mill downtime and mill operating costs. One of the most successful methods is the spray procedure which has been used on a number of different types of mills. In one group of mills which were changed over to spray lubrication, where bearings consisted of both metallic and nonmetallic units, some of the important results effected were:

1. Increased bearing life (on blooming mills bearing life was extended from 3 to 18 weeks).
2. Shop work costs were reduced.
3. Roll necks require less refinishing or dressing.
4. Mill lining delays were reduced to a minimum.
5. Marked reduction in lubricant consumption.

A number of design requirements must be met to obtain such results. These include proper consideration of such factors as:

1. Correct lubricant selection.
2. Proper bearing clearance (on large bearings such as blooming mills clearance should be from 0.06 to 0.09 in.).
3. Proper selection of lubricant application timing cycles.

Many existing mill units offer wide possibilities for more economical operating through such changeovers.

"THE SELECTION AND USE OF A WATER SOLUBLE ROLLING OIL"

by PAUL W. COFFMAN, Assistant General Superintendent, Riverdale Plant, Acme Steel Co., Chicago, Ill.

P. W. COFFMAN

△ ACME Steel Co. has been testing soluble rolling oils, used in the cold reduction of strip steel, since 1953, and since that time 26 products from 10 different companies have been tested. Due to the nature of the material rolled at Acme, the requirements for soluble rolling oils are quite exacting. The following characteristics are considered of importance in a soluble rolling oil:

1. Ease of solubility, and stability of emulsion.
2. Good lubricity.
3. Good wettability.
4. Good performance at a wide range of temperatures.
5. No excessive heat build-up at maximum speeds and reductions.
6. The emulsion must act as a lubricant for work roll bearings.
7. The emulsion must withstand centrifuging without breaking down.
8. Steel must be as clean as possible after cold reduction.
9. Good rust protection after cold reduction.
10. Low unit cost.

Soluble oil rolling solution is used on five cold reduction mills at Acme Steel: two tandem mills, a single stand four-high mill, a single stand four-high reversing mill and a sendzimir mill. For practical reasons it is desirable that the same rolling oil be used in all of the mills. In several of the cold reduction mills, the rolling solution is used as a lubricant for the work roll bearings, as well as couplings and spindle carriers. In the sendzimir mill the solution is used as a lubricant for the backup bearings.

Preliminary testing of rolling solutions is carried out on a small single stand four-high mill, primarily for the evaluation of rust protection and nonstaining characteristics of the product. Final evaluation of rolling oils is made on the five-stand tandem mill which is equipped

with two identical 10,000-gal solution tanks, which can be used together or independently. One tank is charged with the test solution, and the other tank with the standard solution, and the two solutions can then be compared under identical operating conditions. Comparisons are made on mill loads, speeds, strip shape and temperature, strip cleanliness, and general operating characteristics.

Proper usage and maintenance of the solution are extremely important, particularly in regard to the correct per cent of emulsion, PH of the emulsion, and cleanliness of the emulsion. Daily analyses are made on per cent emulsion and PH, and weekly analyses are made on the iron content of the rolling solution.

PH is maintained above 7.4 to eliminate difficulties with emulsion separation. Iron content of the rolling solution is kept below 0.1 per cent by weight in order to maintain strip cleanliness. This is accomplished by either changing the solution when it becomes excessively contaminated or by continuously filtering or centrifuging the solution to remove the contaminants. It is more economical to continuously clean the rolling solution, and far better cleanliness is obtained by so doing.

"LUBRICATION OF REPUBLIC'S 45-IN. SLAB MILL"

by WALTER J. RODENBERGER, Lubrication Engineer, Cleveland District, Republic Steel Corp., Cleveland, Ohio

W. J. RODENBERGER

△THE 45-in. slabbing mill in Republic Steel Corp.'s Cleveland district plant is a 2-high universal direct drive mill equipped with vertical edger, front and back table manipulators, automatic 4-side hot slab scarfer and the other auxiliary equipment usually associated with an installation of this type.

The mill is serviced by several automatic grease, oil and hydraulic systems.

The lubricating equipment and systems, as well as types of lubricants used on this equipment are described. The initial lubrication problems encountered and the correction of procedures and design to solve these problems are discussed.

"INLAND'S NEW AUTOMATIC SLABBER"

by R. J. BEESWY, Superintendent, Electrical Dept., and E. R. McGAUGHEY, Superintendent, No. 3 Blooming & No. 4 Slabbing Mills, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

R. J. BEESWY

△ INLAND'S venture into the field of automation and programming on its new 46 x 90 in. universal slabbing mill has been most gratifying.

Since this mill was one of the first of its kind in the country to be fully programmed, a number of unusual problems were encountered by all concerned with the project. The planning, installation, staffing and operating experience peculiar to this new automatic mill are discussed in this paper.

A departure from conventional electrical equipment on the mill includes a control scheme which incorporates the very latest in switching, sensing and amplifying devices. In order that reduction of ingots proceed at the same or faster rate than that of manual operation, adjustment of all control elements and the location of sensing devices was critical.

E. R. MC GAUGHEY

Attraction, selection and training of electrical maintenance personnel to maintain a mill as electrically complex as this posed a particular problem which was uniquely solved.

Operating techniques heretofore dependent entirely upon human operators were explored, evaluated, redesigned and reapplied to conform with a completely new concept of production control.

Problems of varying degrees of importance had to be recognized and solved for successful application of these new ideas.

Operating experience to date indicates that minor changes will be made but in general the operation of the electrical equipment is as anticipated.

"THE BLOOMING MILL PROGRAMMED!"

by H. G. FROSTICK, General Supervisor, Design Engineering, New Mills Construction, South Works, United States Steel Corp., Chicago, Ill., J. RAYMOND ERBE, Metal Working Section, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa., and MARSHALL BRITTAIN, Manager, Co-ordinated Digital Development, Systems Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.

H. G. FROSTICK

J. R. ERBE

△ THE 20,000 hp used by a reversing mill to produce a bloom or a slab and the movements of a heated 40,000-lb steel mass throughout this process are being controlled by a predictable production method called programming. This is accomplished by transferring the arts and skills of the steel industry's rolling techniques to engineered steps and carefully plotted movements so that modern electrical equipment can be more fully utilized to meet increasing production demands. While program control in rolling steel may help to close the gap between cost and price and aid in keeping the product competitive, this achievement in rolling steel entirely by means of a predetermined series of steps is an engineering breakthrough having a tremendous impact on steel manufacture. Definition of the problem, its solution and its significance are related in this paper.

"IS THE FAULT ALWAYS ELECTRICAL?"

by R. J. BYRNES, Senior Electrical Engineer, Cutler-Hammer Inc., Milwaukee, Wis.

R. J. BYRNES

△ WITH the advent of new and complex automatic processes, the task of pinpointing trouble in the complete system has become more difficult. With a simple control scheme handling a single motor, it was relatively easy to check the location of a fault. The combination of a hundred electrical motors closely tied to a single system and coupled to hydraulic, pneumatic and mechanical motions, any one of which may interact with the others, requires that greater care must be taken to insure that the correction is applied at the source of the trouble.

Many cases of electrical troubles may be corrected mechanically and many mechanical troubles may be rectified electrically with the result that sometimes unnecessary compromises are made.

Circuit monitoring by means of memory fault indicators or annunciators, up to date diagrams, instruction books and operating charts, and adequate meters and performance data help to keep the controllers operating properly.

Proper mounting, maintenance and preventive maintenance, lubrication and ready access to lubrication charts and data can help keep machinery motors and generators at peak efficiency.

Clean traps and filters, periodic checks for line leaks and oil level indicators, all aid in correct and trouble-free operation of hydraulic or pneumatic installations.

But, in the words of the old cliché—the chain is no stronger than its weakest link. The entire system must be considered as a unit. To tie all phases together, there is no satisfactory substitute for a well-trained staff which understands not only the electrical, mechanical and hydraulic components, but also has a working knowledge of the particular characteristics and problems of the process.

"DESIGN DATA FOR BEARINGS OF NYLON, ACETAL, AND TFE FLUOROCARBON RESINS"

by L. H. GILLESPIE, Applications Technologist, and G. S. HUDSON, Sales Technologist, Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

L. H. GILLESPIE

△ NYLON resin, acetal resin, and TFE fluorocarbon resin, are all excellent bearing materials. They are being used in increasing quantities for both lubricated and dry bearings, though by far the greatest field of application is that of the dry bearings.

These materials offer potential cost savings and they possess special bearing properties such as low friction, chemical inertness, light weight and low elastic modulus. Bearings of nylon resin and acetal resin are used without reinforcing compounds. Bearings of TFE fluorocarbon resin are normally compounded with substances such as glass, copper or graphite. These additives reinforce the teflon and provide the strength to withstand heavy loads. The teflon provides the lubricity, or low frictional characteristics, required of bearings.

G. S. HUDSON

The conclusion of recent experimental studies and several years of experience have produced a technique for designing dry bearings of the three plastic materials. This technique is presented along with a background discussion of the effects of changes in the numerous design variables. Consideration is given to such subjects as clearances, surface finishes, shaft materials, PV limits, friction, wear, operating temperatures and compressive stress limits.

"MAKING LUBRICATION MORE EFFECTIVE AS A WEAPON IN MANAGEMENT'S WAR ON WEAR"

by WAYNE G. RITTER, President, Ritter Engineering Co., Pittsburgh, Pa.

W. G. RITTER

△ RISING repair and maintenance costs in steel plant operations is a subject of concern to responsible management. This paper cites 12 years of repair and maintenance cost versus total manufacturing cost ratios for the nine largest steel producing companies in the United States. It is of utmost importance to future manufacturing costs that wear rates of steel-producing equipment be minimized. The principal weapon, one which can do 75 per cent of the job, is good lubrication. Even though lubrication systems have been used for over 25 years and are recognized as having a beneficial effect on costs, they are not doing a good enough job today. Fourteen steps are suggested which can make lubrication more effective as a weapon in managements' war on wear. These are suggestions of a practical nature intended to show how management can use the tools nowat hand to better advantage. Attitudes of operators, engineers and all workers are discussed in order to show how these affect the present state of lubrication in plants.

"FILTRATION IN THE IRON AND STEEL INDUSTRY"

by JOHN R. McCOY, Manager, Technical Service, Indiana Commercial Filters Corp., Lebanon, Ind.

△ THE types of filters and the degree of filtration required in the iron and steel industry are quite varied in nature. Dirty oil will not lubricate machinery properly and will allow excessive wear on moving parts. Properly

J. R. MC COY

applied filters can save many thousands of dollars by maintaining oil and equipment in top working condition. Because of the very nature of some steel mill operation, compromises have to be made in the filtration equipment. Very heavy oils are used in some operations, while comparatively light oils are used in others. Water content is important. Real effective filters are not possible where there is a mixture of soil and water. Where water is a factor, water must be removed continuously or the oil will soon become unfit for use. Metal working coolants must be kept clean to provide long tool life and less rejects. Hydraulic mechanisms must operate on clean oil if trouble free operation is desired. Transformer oils must be serviced periodically or transformer failure may result and shut down the whole plant. Filtration and reclamation of roll oils is highly desirable but is not always economically feasible.

"FILTERING AIR FOR STEEL MILLS"

by C. D. WRIGHT, Steel Mill Application Specialist, Air Filter Div., American Air Filter Co. Inc., Louisville, Ky.

C. D. WRIGHT

△ THE need for clean air in certain areas of the modern steel mill has been clearly defined for sometime. No longer is it necessary to evaluate the merits of air cleaning for electrical ventilating systems, turbo-blower intakes or for laboratory and office ventilation. Without clean air, much of the great progress in steelmaking technology would have been impossible and this fact has become well recognized throughout the industry.

Air cleaning as a specialized art is new as compared to the making of steel, but through diligent research and development the air filter industry has provided many devices which are satisfactory to meet the essential requirements of the designers and users of mill equipment.

A wide variety of air cleaning devices is now available in each of the three basic categories. An air filter may be classified as either viscous impingement, strainer or interceptor type, or an electrostatic precipitator. No one type or basic design of filter can meet all of the various requirements for all of the air cleaning needs in a steel mill. The choice of the correct filter for a specific application depends upon many factors; some of which cannot be accurately measured and thus air cleaning today remains somewhat an art rather than an exact science.

Some of the important items for consideration when selecting an air filter include the type of filter best suited for the space available, the dirt load to which it will be exposed, filter effectiveness or the amount of dirt to be removed, the initial and operating costs, resistance to air flow, maintenance requirements, and, sometimes most important, operator preference and past experience.

It is conservative to estimate the current expenditures for air filters in the steel mills at about one million dollars annually. This does not include installation costs. An untold amount is being spent for maintenance labor and materials. Only by the careful evaluation of all the requirements and complete understanding of the limitations of various air filters, can a choice of equipment be made which will give a reasonable return on this investment and provide the desired protection of men and machines from the ravages of dust and dirt.

"BLOWING METHODS IN STEELMAKING"

by G. M. YOCOM, Assistant to General Manager and L. XIDIS, Steubenville Works, Wheeling Steel Corp., Steubenville, Ohio

C. M. YOCUM

L. XIDIS

△ INTEREST is being revived world wide in pneumatic steelmaking processes. The paper traces start, rise, decline and rebirth of pneumatic steelmaking. The role of raw materials, fuel economy and scrap availability guides choice of process.

Rejuvenation of present air blown processes is possible through the adaptation of oxygen and oxygen/steam mixtures as the blowing medium. Acid bessemer steel has been successfully dephosphorized to 0.015 per cent in the ladle.

A brief description of acid and basic bessemer is presented with transition to the LD and Kaldo processes. The paper compares relative merits of LD and Kaldo including metallurgy, refractories consumption, yields, scrap melting ability and production rates. It gives data on the nitrogen, oxygen, phosphorus and sulphur levels achieved in various pneumatic methods and compares thermal efficiency and expected yield of the different pneumatic processes and the open hearth. The paper concludes with potential of the use of oxygen and briefly mentions OLP and rotor processes.

"EXPERIENCE IN CLEANING BLAST FURNACE GAS WITH THE ORIFICE WASHER"

by G. E. REID, Utility Engineer, Steam Efficiency & Combustion Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

G. E. REID

△ THIS paper presents in some detail the background of, and the operating results from, the use of the orifice washer in blast furnace gas cleaning at Pittsburgh Works Division of the Jones & Laughlin Steel Corp. Pittsburgh Works is a large integrated steel plant and its facilities include six iron producing blast furnaces, ranging in nominal capacity from 850 to

1350 tons per day.

The first orifice type washer for blast furnace gas cleaning was installed in 1955. Since that date, all six furnaces have been equipped and are using this gas cleaning method in conjunction with the conventional type wet washer. Dust loading in the cleaned gas has been reduced to a level which is appreciably below that attained by use of the conventional wet washer tower scrubber. Although the use of the orifice washer system has created no maintenance problem, it does require the development of a small increment of additional power at the blown air source to compensate for the permanent pressure loss sustained by the gas flow past the orifice.

Data are included in the paper to indicate typical dust loadings for cleaned and uncleaned gases, water flows and orifice pressure drops as found on the several orifice washer installations at Pittsburgh Works. Of interest is a tabulation and chart illustrating the actual material build-up within the vertical gas duct upstream of the orifice face and the pressure drops associated with this constriction of duct area. Treatment is also given in the paper to various methods of supplying service water to the dirty gas stream at points upstream of the orifice face. From this experience, it is believed that this system detail is relatively unimportant.

"SANDWICH ROLLING"

by H. S. ORR, Project Development Engineer, Rolling Mills, United States Steel Corp., Pittsburgh, Pa., and FRANK R. ROMEO, General Foreman, Sheet and Stainless, Homestead District Works, United States Steel Corp., Munhall, Pa.

H. S. ORR

△ THE aircraft and missile industries have established a trend toward higher strength materials and temperature resistant materials which have design capabilities beyond the traditional construction metals. These industries need a full complement of mill commodities; the most important raw material commodity needed is sheet. Axiomatically, *very large* sheet products are needed for good design. The problem of manufacturing larger sheets for aircraft and missiles is greatly aggravated by the type of alloys needed. Temperature resistant materials as well as constructional alloy steels and the higher chromium martensitic and precipitation hardening steels typify the grades having the most design attractiveness. These materials, because of their superior elevated temperature strengths, also resist deformation in hot rolling to a greater extent than do carbon steels. In addition, many of the compositions have restrictive rolling temperature ranges and are characterized by their disposition toward edge cracking and surface deterioration on rolling.

F. R. ROMEO

The numerous demands of the aircraft and missile industries suggest that needed steel production capability can be realized only by expanding the methods and technology of conventional manufacturing practices or by the use of novel methods of manufacturing.

The United States Steel Corp. has responded to these demands by investigating the feasibility of both methods by achieving the end product. This paper will discuss the results of investigations pertaining to one aspect of the U. S. Steel program to develop novel methods of manufacturing. This most promising novel method of sheet manufacture is a process which has been titled "sandwich rolling." Thin wide sheets of difficult-to-roll stainless and alloy steels have been produced on hot strip and plate mills by the sandwich rolling method.

Conventionally rolled alloy or stainless plates are assembled between heavy gage carbon steel plates. The composite assembly is then enclosed with side and end carbon bars and then welded. This fabricated slab is heated and rolled on the same facilities that are used for heating and rolling carbon slabs. After rolling, the assembly is heat treated, flattened, and sheared. After shearing, the sheets are separated from each other and finished for shipment.

A substantial amount of material has been produced in a wide variety of grades, including the H-11 type die steels, USS Stainless W, PH 15-7 Mo, USS 12 MoV, AISI 4340, USS Airsteel X200 and M300. Sheets up to 140 in. wide have been produced. Crown usually associated with flat rolled products is virtually eliminated in this process. The company has produced in excess of 2500 sheets, and the performance in meeting thickness tolerances which are approximately one half of standard has steadily increased. On high carbon martensitic type steels, decarburization has been minimized by the use of this process.

Some of the known measurable improvements in sheet products demonstrated by the sandwich rolling process are: (1) large sheet availability, (2) closer gage control, (3) minimization or elimination of crown, (4) minimization or elimination of decarburization, (5) improved hot rolled surface, (6) reduced mechanical property directionality and (7) potential of contour or taper rolling.

"MATERIAL AND DESIGN DEFECTS IN FORGED STEEL ROLLS"

by A. A. BRADD, Co-ordinator of Rolls, Midvale-Heppenstall Co., Nicetown, Philadelphia, Pa.

A. A. BRADD

△ DEFECTS in the material of rolling mill rolls can result in poor roll life, premature roll failure and a lowering of the quality of the material being rolled. The description of some typical defects and their effect on roll performance and on the product rolled illustrates the necessity for controlling all steps in roll manufacture to hold the size and quantity of these harmful defects to a minimum. Nonmetallic inclusions in rolls are probably the defects

most difficult to control in conventional air melted steel. New melting processes are showing the capability to produce steel with fewer and smaller defects, and rolls made by these processes have advantages over conventionally made rolls. Consumable electrode vacuum arc melting and vacuum pouring are two of the newer melting methods used to manufacture roll steel. Design features can also result in premature roll failures because of high stress concentration or other reasons. A few examples are described to show how simple design changes can sometimes have pronounced beneficial effects. As rolling speeds and loads increase and surface finish requirements become more stringent, continued improvement in quality will be required to produce rolls that will satisfy the ever more severe requirements of the roll users.

"SALIENT FEATURES OF ARMCO'S NEW HOT STRIP MILL, BUTLER WORKS"

by CYRIL H. ROBERTS, Supervising Mechanical Engineer, and THOMAS M. KILGO, Senior Electrical Engineer, Butler Works, Armco Steel Corp., Butler, Pa.

C. H. ROBERTS

△ THIS paper describes the recently completed hot strip mill at the Butler, Pa., works of Armco Steel Corp. Slabs 4 to 8 in. thick and 12 to 52 in. wide are received from the slab mill and stored in the new slab storage building. The slabs are reheated in three triple-fired continuous-pusher-type slab heating furnaces. From the furnaces, the slabs progress through a two-high scalebreaker, a four-high reversing universal mill and then through five 4-high finishing stands to coiling facilities consisting of two 26-in. mandrel type downcoilers. Coils are discharged from either of the two coilers and are transported to coil storage areas by a conveyor.

T. M. KILGO

After traveling on the conveyor below floor level, the coils are weighed and discharged into one of two buildings where they are stored prior to further processing.

The hydraulic descaling system, oil cellar, fume and dust removal systems, strip cooling spray system, cooling water system and roll shop are reviewed in the paper.

The electrical discussion covers the hot mill power distribution system, the motor room, motor room ventilation, main power supply motor-generator sets, main mill drive motors, motor control centers for a-c auxiliaries, and the electrical control of the drives for the mills, tables and coilers.

Each of the main drive motors has its own supply generator. Each coiler has its own power supply, motor-generator set and control allowing the coilers to operate independently of each other.

The paper covers these and other salient features of the new mill from both a mechanical and electrical standpoint.

"FAIRLESS WORKS, SHEET AND TIN DIVISION, INDUSTRIAL WASTES TREATMENT"

by WILLIAM A. SECH, Technical Coordinator, Maintenance and Utilities Div., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

W. A. SECH

△ THE Fairless Works plant of United States Steel Corp. was built with industrial wastes treatment facilities that incorporated the latest designs for steel mill application that were available at the time. The installation that resulted was one based on the theory of utilizing waste products to reduce, oxidize or neutralize other wastes with a minimum of costs to the operators for virgin waste treatment chemicals.

To arrive at this design much research was necessary to determine the analysis, nature and amount of waste materials that would have to be handled. The nature of the material was easily defined, however the analysis and amounts of waste materials were not. This was largely due to the fact that industrial wastes treatment for many years was considered adequate if a large pit or body of water was available for disposal purposes. The advent of more rigid state laws, regarding stream and air pollution, brought about serious study of this problem and resulted in a significant discovery by many industries that they were literally washing thousands of dollars worth of recoverable materials down the drain or else spending countless thousands for neutralizing chemicals while disposing of these same chemicals elsewhere in their own plant.

This paper deals with the design and operation of The Fairless Works sheet and tin mill waste treatment plant. It traces the origin, nature and amounts of wastes as they are received for treatment and the problems that arose which necessitated changes to effect a more efficient and easier to run plant.

"TECHNOLOGY OF BASIC BRICK"

by GEORGE R. EUSNER, Division Chief—Refractory and Mineral Technology Div., Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

G. R. EUSNER

△ THE physical, mechanical, chemical and petrographic properties of new and used basic brick are discussed with special emphasis given to basic open-hearth-roof brick. The necessity for narrow quality control limits on the purity and grain sizing of the chrome ore and the periclase used in basic brick are pointed out, as well as the necessity for controlling the processes employed in the manufacture of basic brick. The processing variables that have the greatest influence upon brick quality are covered in detail. Photographs and photomicrographs of used basic brick are shown to illustrate the mechanism of deterioration during service. Consideration is given to future development in the technology and application of basic brick.

Foreign Competition— A Challenge To American Industry

by D. S. Holbrook, President
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HERE I wish to bring before the AISE a subject which is not strictly engineering but which in some of its implications directly concerns all of us as engineers—and that is the problem of the coming competition from overseas producers which lies ahead of us in North America and its implication for the steel industry engineers of the 1960's.

In the last year the United States steel industry has become much more conscious of overseas producers. The current labor negotiations have emphasized the problem of low price competition and there have been claims and counterclaims by management and labor as to the reasons therefore, but this problem definitely is not a transient one and I believe that the newly recognized overseas competition must be regarded as one of the prime influences in our steel business of the 1960's.

D. S. Holbrook (left), with J. L. Laidlaw, also of Algoma Steel, and Emil Kern of Allegheny Ludlum Steel Corp. Mr. Laidlaw is chairman of the Detroit district section of AISE. Mr. Kern is president of AISE.

Canadian steel has been much more sensitive to foreign competition than has the industry in the United States. Our industry, is less than one-fifteenth the size of the industry of free Europe, and one-third the size of Japan. Surpluses from these countries can be sold advantageously in Canada with our low tariffs and the traditional Canadian willingness to sacrifice manufacture in order to sell grains and forest products. We are used to importing about a quarter of all the steel used in Canada, and have long felt the shocks of violent price fluctuations inherent to overseas steel offerings.

The United States on the other hand has been a net exporter of steel since the turn of the century and for years the largest steel exporting nation in the world. This has changed, and unless world trade is badly disrupted, a strong overseas competition is something North America is going to have to live with. Figures of the United States Department of Commerce show that in the last six months, imports to that country have greatly exceeded exports, and in some months by as much as two to one. The American steel industry as a whole is increasingly recognizing this new competition and is beginning to show signs of worrying about it. To some of the smaller steel companies in the United States who depended on wire and reinforcing bar sales for their prosperity, it has progressed from being an irritant to a major problem.

There are a number of important contributing reasons for this situation.

First—overseas costs are lower. High wage rates are primarily to blame; employment costs in the United States and Canada are approximately triple those of Europe and six times those of Japan. Even though man-

hours employed in the production of steel are currently lower in America than overseas, the dollar multiplier of the labor content is so great that labor costs for a long time have been, are, and will be far greater than those of the overseas producer. While raw material, fuel and power costs are mostly higher overseas than normally experienced here, these are overshadowed by the predominance of their cheap labor.

The second reason is that transportation and distribution channels of overseas steel are better. The St. Lawrence Seaway offers a new contribution to economical shipment of overseas steel products to the great part of steel-consuming America and the coming years will see ever-growing use made of this route. Ocean freight rates in general are more stable and favorable to Continental producers than they have been in the past. As coal comes into surplus supply in Europe, vessel charter rates have become cheaper, and as a result the very important cost of freight from Continental Europe is currently only about one-half of what it was a few years ago. Fine new port facilities in Europe are becoming the rule rather than the exception—the devastation of the Second World War has been removed, and more efficient dock handling has taken its place.

There is no denying that distribution facilities have improved. Overseas delivery promises are increasingly responsible and better credit facilities for importers has made overseas commerce easier.

A third reason is that America is looking increasingly attractive to overseas producers as the former "have not" nations construct their own steel making facilities. The formerly lush export markets of the European mills in South America, Africa, Southern Asia and the smaller European countries are disappearing as new steel mills are built all over the world. The removal of countries behind the Iron Curtain from the commercial sphere of influence of the E.C.S.C. producers has made it necessary for them to look to the West. These factors have necessitated a realinement of world steel trade and American steel prices are looking better to Continental producers as world prices go down.

A fourth, and the big overruling reason is the obvious one—overseas producers are increasingly competing for the American market because they are becoming equipped to do so. With their rejuvenated plants the overseas industry today is a different industry from ten years ago. Too many of us in management, operations and engineering have been lulled into a state of complacency due to the supposed superiority of American "know-how." This can be translated as a mild contempt or ignorance of the other steel industries of the world. Too often there exists a soft, warm feeling that American "know-how" will overcome engineering advances made by overseas producers.

This is not for lack of information. Anyone reading I. E. Madsen's "Developments in the Iron and Steel Industry," and the excellent summaries of other authors published in the *Iron and Steel Engineer* in recent years, has noted the extensive developments of the industry in Europe and Japan. We have been reading these fine engineering descriptions without realizing their long range implications—that there is rapidly growing in Europe a more modern steel industry than on this side of the water.

What has brought about this great change in the relative status of the world steel industries? Let me give you a little history.

In the years following the First World War a highly competitive situation characterized by surplus capacity arose in the European steel industry. This developed first out of the very rapid expansion in plant in response to war demands that had taken place in certain countries, notably the United Kingdom, and which proved in excess of peace-time needs. Second, the reconstruction and modernization of plant in countries that had suffered severely during the war, as in the case of Belgium and France, served also to further expand productive facilities. A third factor that tended to heighten international competition was the shift in customs boundaries, involving the transfer of Lorraine, the Saar and Luxembourg from the German customs area to those of France and Belgium. Finally an unsettling element in the pattern of international trade during the 1920's was provided by the currency depreciation in certain steel producing countries, notably France and Belgium.

The combination of these conditions contributing to a very high degree of competition in the European industry was in itself conducive to additional investment, which naturally tended to place the European industry in a weak position if earnings declined. When the depression came along, prices fell along with production, and indebtedness of the industry to the banks resulted.

One author states that the history of the European steel industry in the period after the First War can be characterized by three phases: the initial period of growth starting in the mid-1920's; the collapse in the face of the depression; and the revival dating from the early 1930's. The revival was characterized by the formation of the national and international cartels of Europe whereby prices and output were fixed. Trusts were formed of large producers and world trade carved up nicely. The United States Tariff Commission in 1938 reported that the Continental Steel Export Cartel represented two-fifths of world steel production and controlled five-sixths of international trade in steel. The United Kingdom felt the influence of the continental trade cartels and in turn set up very high duties.

None of these trade arrangements was conducive to growth, modernization and improvement in efficiency and acted as a brake on the capital expansion of the industry.

The situation in the European steel industry during the 1930's is summarized in the following manner by Derek Bok, in writing on "The First Three Years of the Schuman Plan," Princeton Studies in International Finance, No. 5, 1955, "For years before the Second World War, investment in the steel industry had been discouraged by the policies of an international cartel which operated behind tariff walls to regulate production, restrain competition and preserve to each member nation the right to exploit its own domestic market. Moreover, inefficient installations had long been kept alive by government subsidies while import restrictions served to limit the markets of efficient firms and thus prevent consumers from utilizing the cheapest sources of supply."

The Second World War is fresh enough in the minds of those present to appreciate what happened in the

1940's. The industry in Germany lay in ruins with its most modern equipment removed to Russia as reparations. France's industry was in a bad state of repair and needed complete rehabilitation. Much of Great Britain's industry was worn out, and to a considerable extent, obsolete.

It took almost five years after the close of the Second World War for the European industry to get a second wind and formulate sweeping changes of modernization and expansion.

A somewhat similar situation existed in Japan. The small Japanese industry of the 1920's which had grown greatly in the 30's maintained production at an almost constant pace from 1937 to 1944 and then with the close of the war and the removal of Manchuria from Japanese influence, the industry suffered an abrupt collapse.

The 1950's, however, are another story for both Europe and Japan. The rejuvenation of the overseas industry which was planned in the late 1940's became a reality in the 1950's assisted by over $1,000,000,000 of seed money in grants, credits and loans from United States government agencies and indirect assistance through the World Bank.

In the decade from 1950 to 1960, the rise in efficiency and capacity of the overseas industries is astonishing and it has been accompanied by marked improvement in quality of its products. In North America, our annual capacity has risen from 104,000,000 tons in 1950 to an estimated 159,283,000 tons by the end of this year, or 54,283,000 tons. The closest corresponding figures available for the free world countries actively engaged in iron and steel international trade—I refer to Great Britain, free Continental Europe and Japan—indicate a rise from an output of 62,597,000 net tons in 1950 to an estimated capacity of 135,717,000 net tons by the end of this year or 73,120,000 tons. While the rise tonnagewise of our overseas competition is somewhat greater than our own, percentagewise these overseas producers have increased approximately 117 per cent while the North American increase is 52 per cent.

Beyond this the overseas rise has been accompanied on the whole by a far greater degree of rehabilitation and addition of new equipment than has our own.

Let me give a few examples. Since 1950, North America has installed or has under construction 37 blooming mills. The overseas countries I have mentioned appear to have installed or have under construction 40. North America, 16 hot strip mills—our overseas competitors, 31; North America, 1 structural mill—overseas, at least 6; North America, 4 plate mills—overseas, 30; North America, 15 merchant and light section mills—overseas, at least 28; North America, 7 rod mills—overseas, 14.

These figures are impressive particularly when we consider that the aggregate capacity of the countries mentioned is still less than North America's.

Have no illusion that the equipment installed is far inferior to our own. In many cases it is the same, as the American mill builders have been busy selling equipment in Europe and Japan and a large percentage of the load of the American heavy steel manufacturing equipment makers in the last decade has been for overseas customers. An hour of engineering time costs much less in Europe than it does here and most of the installations I have seen in Europe are well-engineered and carefully planned.

The argument is often heard that American mills are more efficient than European as reflected by the man-hours consumed in making a ton of steel and all sorts of statistics have been cited to prove this. Do not become complacent upon reading them. In some cases it is foreign government policy to provide employment in mills in "make-work" jobs, but key operating positions in the newer mills are usually about the same as here. With the benefit of good equipment, production rates will continue to rise as surely as they have on this side of the water. It is interesting to note that in Japan in the last five years tons of rolled steel products produced have increased by 64 per cent while work-hours engaged in their production increased only 12 per cent.

As the European currencies have become more stable in the last few years and money has become available to the mass of European workers, it is not all going into hiding; the general public is beginning to invest in steel securities. Interest rates are more stable and Europe is increasingly in a position to raise money for further expansion on its own. The seed money made possible by American generosity since the War has now begun to flower. The steel revolution has been so world-wide and so profound that as overseas producers digest their new plant and continue to expand their industry, North America, with its attractive markets, will increasingly lure the overseas producer.

The vigor of the European steel industry today will certainly continue to grow in the 1960's and we must expect strong, capable foreign competition with continually improving quality and better deliveries. With this prospect in years ahead, we should be worrying less about our neighbor across the state line who is building a five-stand tandem mill to run at 8,000 fpm, when our own will run at only 7,000, and worry more about our competitors across the water who are building whole new steelworks.

What are we going to do about it?

We are all going to have to pitch in and work in the 1960's, and the engineer is no exception.

We in Algoma believe that overseas competition will cause all of us a lot of hard work in the 1960's and we are going to pay strict attention to four components of operations: men, money, materials and machinery.

Our men, both in management and labor, will have to work extra hard. The 40-hour week will have to be an honest forty hours on both sides of the labor-management fence. Management will have to effect every potential economy in labor utilization as we must appreciate that for every man we can afford to employ, our foreign competitors can afford to employ three. Management will have to put every segment of our steel business under a magnifying glass in an effort to seek improvement.

Labor will have to work much harder. No one can go through a steel mill today without realizing that a great deal of seniority in work practices is being observed—"feather bedding" is another name for it. Labor will have to co-operate to eliminate this drain on our steel economy. We are in the unfortunate position of watching normally intelligent and progressive labor leaders being carried along by the sheer inertia of historic work practices.

Money will have to work harder. With the continued opportunity for replacement and improvement that exists in North America today, we should plan maximum cash flow in the form of lower operating costs, better depreciation allowances and lower taxes. We will have to get along with the minimum necessary working capital. Money sitting around in short term securities is not working as hard as it should. Wages and benefits have increased to the point where it costs more than $25,000 per year to staff a single production job around the clock in our mills. We can put a lot of money to work in the form of better equipment for a return of $25,000 a year.

Materials must be continually improved and we should not forget that it takes money to do this. One of the steel industry's most constructive accomplishments during the 1950's has been recognition that up-graded materials play a strong part in improving the efficiency of the industry. The overseas mills have done a great deal of work on beneficiation of ores and improvement of low grade coals for as long or longer than we have.

The last component of operations is machinery or physical plant which is a responsibility of the engineering profession. I believe that the 1960's will see tremendous improvement in equipment design; we look for these improvements to come predominantly from the equipment builders and steel mill engineers of the United States. This improvement will have to come as pressure on North American steel prices continually mounts. Competition will become more severe due to low manufacturing costs of overseas producers and the competition of other domestic producers with new equipment. We can also be sure that the pressure of government and public opinion and competitive materials will tend to keep steel prices at a rock-bottom minimum.

The majority of steel mill equipment of pre-World War II vintage will have to be classed as only marginally competitive and will have to be replaced if the steel producers owning such equipment want to stay in business.

In the United States this will have to be accompanied by depreciation tax law reform early in the 1960's. Undoubtedly this will encourage investment in steel and unleash a tremendous demand for new equipment. Equipment makers will be forced to fill the needs of smaller works and producers. There are 146 steelmaking works in the United States according to the Directory of the American Iron and Steel Institute; less than one-third of them possess over 1,000,000 tons of annual ingot capacity; less than one-sixth, over 2,000,000 tons; and less than one-twelfth, over 3,000,000 tons. The slabbing mill or strip mill which will produce 3,000,000 tons a year will be of scant interest to nine out of ten works but the small staffed, medium tonnage mills are going to be a tremendous attraction.

It is going to take a lot of fine engineering talent to meet these requirements. The available investment dollar will have to cover as broad a range of equipment as possible. We in Algoma, and I think a large number of other steelmakers, will not be interested in the biggest or the fastest or the heaviest of anything. We will look for equipment and processes which will give us the cheapest steel output taking into consideration both operating and investment costs. We will look for a decrease in the cost of installing equipment, and a reduction in the cost of buildings and foundations.

Engineers of the 1960 decade are going to have to get a lot closer to the financial people. They are going to have to have a clearer understanding of the workings of depreciation and taxation as it affects their recommended investments.

The engineers are going to have to get a lot closer to operations and in turn sell the operators on investment principles as it affects the equipment the operators want.

The next decade will be an exciting one for engineers in the steel business, and it will be an interesting one. ▲

Midwest Steel Breaks Ground on August 18

The first section of the new plant of Midwest Steel Corp. will be laid out as shown in this sketch. George M. Humphrey, board chairman of National Steel Corp., and Governor Harold W. Handley of Indiana officially broke ground for the plant on August 18. Located at Portage Ind., about nine miles east of Gary, the new National Steel subsidiary will process hot rolled coils from National's Great Lakes Steel Corp. plant at Detroit into tinplate and hot finished, cold finished and galvanized sheet material. The plant as now planned will cost about $100,000,000, and will employ about 2200. It may later be expanded into a complete integrated steel plant.

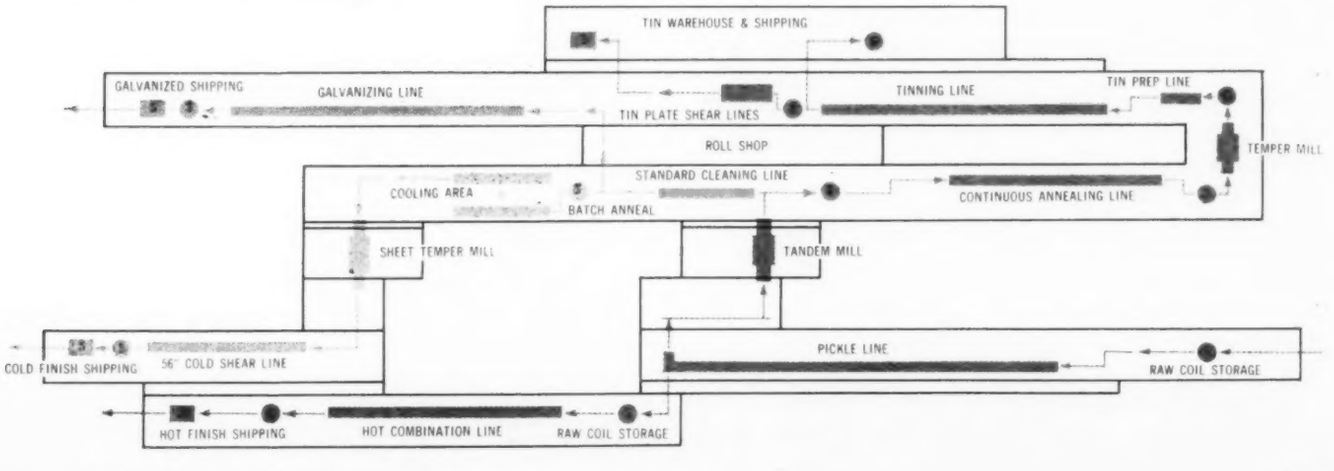

Figure 1 — Electronic computer installed at Ford Motor Co.'s Steel Div. is of the magnetic drum type with a capacity of 20,000 digits.

Electronic Data Processing

. . . . future applications of electronic computers seem to be unlimited . . . .

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ELECTRIC data processing, or electronic data processing as it is often called, is a term that implies the use of that interesting and relatively new device, the electronic computer. The term has this suggestion because the computer has been the most publicized development within the broad field of electronic data processing.

The term could also represent many other useful electronic developments not necessarily related to computers. The paper will cover some of each.

An article about electronic computers, appearing in a recent issue of *Business Week* magazine included a very startling comment by Ralph J. Cordiner, Chairman, General Electric Co. He said, "When the history of our age is written, I think it will record three profoundly important technological developments:

1. Nuclear energy, which tremendously increases the amount of *energy* available to do the world's work.
2. Automation, which greatly increases man's ability to use *tools*.
3. Computers, which multiply man's ability to do *mental work*."

He completed his statement by saying that some of our engineers believe that of these three, the computer will bring the greatest benefit to man.

Many will think that this is absurd, as I did, when I first read the statement. However, after thinking about it a while, I changed my mind by expanding the statement to also include other forms of electronic data processing and by recognizing the fact that new developments in one field can set up a chain reaction of developments in many other fields.

Already computers and other forms of electronic data processing have made great contributions to such widely different fields as guided missiles, nuclear physics, translating foreign languages, composing music, making tools, forecasting weather and operating production equipment.

The most widely publicized feature of a computer is its speed. Everyone knows how fast sound can be converted to pulses and travel over a telephone wire. Data can also be converted to pulses and travel over wires at the same high speed.

One of the familiar ways to do this is with the dial of a telephone. When a "2" is dialed, it generates 2 pulses.

When a "7" is dialed, it generates 7 pulses. There are many other ways to convert data to pulses, and some of the devices which do this can operate at extremely high speed.

An electronic computer is equipped with devices that can count the pulses at electronic speeds. Computers also have electronic switches which can distribute the information into holding areas, filter out or rearrange the information and recollect it. Hundreds of thousands of information pulses per second can be digested by a computer.

All of this tremendous speed in chasing information through a computer is important but the *most* important feature of a computer is its capacity to *hold* information and release it quickly, when it is needed. This feature is commonly called the memory of the computer.

ELECTRONIC MEMORY

Electronic memory is an important advancement because it not only permits storage of information, but also permits storage of a program of *instructions* that will govern what is to be done with the information.

There have been many ways to store information in the past that are still just as useful as they ever were. The advent of electronic memory in computers has helped to give a better assortment of tools, to cover the full spectrum of data processing requirements, from simple jobs to complicated jobs.

Review, for a moment, some of the various ways that information is stored. In order for the storage of information to be compatible with electronic data processing systems it must be stored in some way that can automatically be converted to pulses and played back on demand.

Punched cards and teletype tapes are some of the common storage methods that can be converted to pulses to meet this compatibility requirement.

There are some developments that could make a *printed page* a compatible storage medium. This is accomplished by elaborate scanning devices that test each numeral or character for its horizontal and vertical composition and converts each to equivalent electronic pulse language.

Other comparatively new information storage devices are *magnetic tapes and disks, and magnetic drums and cores.* They have made great contributions to the advancement of electronic computers because they can shovel information into a computer at a rate that can keep pace with its high-speed digestive system.

The storage of information on magnetic tapes and disks is about the same as recording sound on a tape recorder. Another similarity is that duplicates can be reproduced, and information may be dubbed in or deleted.

Instead of a microphone, the initial recording is usually made from a playback of punched cards or perforated tape.

In order to get at *small pieces of information*, some magnetic tapes are broken up into small reels mounted side-by-side, and disks are mounted in a stack like a juke box.

Traveling sensing heads jump around from tape to tape or disk to disk, recording or playing back small pieces of information. In this way any piece of information can be selected in about ½ second from the 10,000,000 or 20,000,000 digits that can be stored in such systems.

A magnetic drum might be visualized as a barrel, wrapped with many loops of magnetic tape. Each loop has its own recording and sensing head.

Rapid access is gained to the information stored on the drum by rotating the drum at very high speeds. The speed is increased to a rate that is almost beyond comprehension by activating all of the sensing heads at one time.

Even at this rate it is still far short of the speed of light.

Incidentally, as the speed and memory capacity increases, the cost increases. It can range from hundreds into millions of dollars; therefore, you can see how important it is to avoid buying more speed or capacity than is needed.

One of the *fastest* memory devices *is a magnetic core.* It looks something like a small piece of window screen. At each intersection of the fine cross wires, there is a small *hoop* or ring, that can be magnetized or demagnetized, which in effect, stores or erases information.

A bank of magnetic cores will store up to 100,000 digits of information in some of the large computers. Every one of these memory positions may be activated thousands of times a second at speeds that do approach the speed of light.

Even at this speed, there is no difficulty in locating the information. Every part of the memory unit is indexed and if the location of the information is known, where to find it is also known. If you do not know where it is stored, you can electronically probe every memory cell in a fraction of a second.

The question may be raised as to how information is initially stored in the memory of high-speed computers. It is generally laid out in the memory, by a playback of magnetic tape or punched cards, where the information was previously stored.

Transducers may convert readings from instruments and meters into pulses for direct introduction into computer memories. However, such readings are usually collected into the intermediate stages of cards or tape.

There are four major reasons for storing information. They are:

1. For repeating information.
2. For communicating information.
3. For controlling equipment.
4. For processing information.

Within each of these categories, there are various requirements as to speed and volume. How some of the different storage methods are used, in each of these categories, will be explained.

REPEATING INFORMATION

The simple job of repeating information is one of the high cost items of any business. I would estimate that up to 70 per cent of the information contained in the tons and tons of paper required to run a business is repeat information or developed from repeated formulas.

An example of some of the things that are repeated many times on different documents and reports are

prices, operating practices, customer names, sizes, time standards, employee names, payroll rates, inventory classifications, account numbers, inspection practices, product identification, purchasing specifications and many many other things.

Unfortunately, if some of this vital information is repeated incorrectly, it can cause many costly mistakes such as producing steel to a wrong size, losing a customer, ordering the wrong material or paying the wrong employee.

There are many ways that electronic data processing can shortcut this job of repeating information and simultaneously reduce the possibility of error. A simple example is a file of perforated tapes in which an assortment of repeat information has been stored. The appropriate tape can be played back on a typewriter to print out things like personnel lists, inspection practices, advertising form letters, production practices and purchase specifications.

Where listings of several thousand items are required such as personnel records or parts catalogs, the information can be stored on tabulating cards and played back through typewriters or larger printers.

Where huge listings of tens of thousands or hundreds of thousands of items are required such as stockholders lists and mailing lists, the information can be stored on magnetic tape and played back through high speed printers.

I have frequently asked electronic engineers why a coil of steel going through a mill could not work like a tape in a tape recorder. In this way it could continuously play back its chemistry and order identity from some kind of nonvisible spots such as magnetic spots, radioactive spots or fluorescent spots.

There are many variations that can be made to each of these card and tape systems when only pieces of information are to be played back.

All of the specification information is printed on our daily mill schedules with one of these variations. We do this from a file of tabulating cards set up for each order on the books. When the order is scheduled, the corresponding tabulating card is pulled and played back on a typewriter to print out all the rolling and shearing specifications, and other related information on the schedule. The cards are used over and over again each time the order is scheduled.

Complete inventories of thousands of items are sometimes stored in the juke box or disk type of memory systems. A small computer is usually coupled to keep the inventory up to date. The status of any inventory item can be repeated at any time by quizzing the memory from a keyboard.

Where inventory information has to be played back in different arrangements such as by size or heat number or location, tabulating cards may have more flexibility than the magnetic disk storage.

We built a system around this principle several years ago, for our productive inventories. It consists of a file of tabulating cards for each ingot, slab, coil or bundle of steel in the production pipeline. The file simulates the complete production flow, in that cards are put into the file as ingots are produced, and advance through the file as processing occurs at each operation. The cards come out the other end of the file when the steel is shipped. The advancement through the file is a relatively simple manual job of pulling and putting cards.

Each day, the file of cards representing the inventory, is played back into a summarizing machine which, in turn, makes a print-out of multiple copies for all persons concerned with the inventory. These print-outs not only give reference to the identity of the material available for scheduling but also indicate the exact bay in which the material is stored or the railroad car number and track, if the material is in transit to a storage yard. It provides information as to the age of the inventory and many other important statistics. The results of this system have been very successful.

Formerly, we had five different departments maintaining inventory records to tell what we had, where it was, its dollar value, its condition, and its age. It was impossible for all of these records to be in agreement, and it was the source of many conflicts. Today, we have one inventory record, and everyone concerned receives a carbon copy of the daily print-out.

The inventory is extremely accurate. A recent physical inventory disclosed that during the past year, the inventory record has followed every single production move and is still in 100-per cent agreement with the physical condition. In former years, we sometimes had experienced large dollar adjustments in the total inventory value and also large adjustments to be made between each product category. Obviously, such a high degree of error caused many false moves from the scheduling and production standpoint. Today, we have complete accuracy 365 days a year through this unique form of data processing.

This system coupled with other production control features has received a great deal of interest in the industry.

Since then, people from most of the major steel companies of the United States, Canada, Brazil and England have visited our offices to review the system in detail. Some of them are now working toward the installation of a similar system.

This system is fully integrated with a number of other electronic data processing systems, and therefore, there is absolute uniformity of information in the related systems. For example, the tabulating cards representing production, which feed the inventory files, are also used for costing production and calculating incentive performance.

This job of calculating incentive performances is a good example of a *computer* being used to select pieces of information that are to be repeated.

In the memory of our computer are stored thousands of time standards for each size variation that can be produced at each operation. When production information is fed into the computer, it instantly scans the standards and selects the appropriate one for calculation of earned hours and incentive performance.

COMMUNICATING INFORMATION

A simple example of information stored for communication purposes is the perforated tape used for teletype. It is not impossible, that magnetic tape will someday be used for this purpose, to transmit messages at very high speed.

Information contained in tabulating cards is now transmitted from coast to coast to recreate a duplicate

file of cards at the other end of the line. A common use of this device is for collecting information from sales offices and warehouses.

We would like to see someone invent a simple and inexpensive data communication system from soaking pits to blooming mills and from hot strip reheating furnaces to various stations along the hot strip mill. Teletype could do this, of course, but it requires more than that. It should start with a simple memory and tally device which stores information relative to the identity and quantity of the materials that are in the furnaces. As the steel comes out of the furnace it should automatically release the information from the memory storage unit and relay it to the mill.

In our mill, an interesting electronic communication system was set up between our various shipping docks and our central shipping office. It is a wire photo device called a facsimile process. It operates by photoelectric scanning that is similar to units used by news services to broadcast photographs cross country. It is used to transmit loading information into the shipping office where shipping papers are prepared, and also to inform the shipping docks as to the status of orders.

This communication system does not generate pulses that are compatible with other forms of electronic data processing.

CONTROLLING EQUIPMENT

Among the four reasons for storing information, examples of repeating information and communicating information have been reviewed.

The third reason for storing information has to do with the control of equipment, which may be one of the most useful branches of electronic data processing in future years.

A simple form is a rotary switch. Three contact points could do three things in a sequence such as turn on a red light, then a white light and a blue light or turn on three motors in successive steps. Each time the switch was rotated, the steps would be repeated in the same sequence.

Three punched tabulating cards or a perforated tape could do the same thing. Each punch, in effect, is a switch which completes a circuit to turn on power, and the absence of a punch turns off power.

The advantage of the tabulating card over the fixed rotary switch is that any number of steps can be added to the sequence by merely inserting more cards. In data processing terms, the capturing of a sequence of steps in some form that can be played back is known as a stored program; a few blooming mills have been using a variation of this principle for some time.

A prepunched card representing a specific rolling practice is selected from a file and put into a card reading device which causes various circuits to be completed for operation of screwdowns and other mill settings.

The circuits completed by punches in cards are very feeble and must go through other circuitry and amplification stages before tying into the heavy duty relays and switches of a rolling mill.

The cards that are prepared usually contain only one rolling practice per card. It is conceivable that there could be dozens of cards available for each product specification, representing one normal practice and many alternate practices. If a small memory unit was added to the card reader, all of the alternate practices could be stored in the memory at one time.

Certain tests could be made by instrumentation to tell the memory device that an abnormal condition existed such as an ingot that was too hot or too cold. In this case, the memory could shift over to another area to select the mill setting most appropriate to this abnormal condition.

Instrumentation of this type which selects the appropriate routine from many alternate routines stored in the memory might be called feedback. There are other technical uses of this term, but for lack of a better word, we would like to use it this way for our nontechnical discussion.

Another variation of this stored program concept is used by one of the major aircraft companies. All of the sequence of settings to be made on a lathe or milling machine, in shaping a part, are stored on a perforated tape. When the tape is played back, it automatically sets the machine and makes the part. Punched cards could also be used.

This could be a useful thing to consider in some steel mills as a substitute for stocking certain expensive replacement parts. If they can be made on a lathe or milling machine, they could be quickly made as they are needed. This development is still in its infancy.

It is not inconceivable that this principle of a stored program could someday be applied to many other operations such as controlling a crane or lift truck to make roll changes at high speed.

A program stored in a high-speed memory unit, such as a computer, has great advantages over programs stored in cards or tape. The selection of alternate routines from cards requires finding and pulling the cards that represent the appropriate routine. In the case of high-speed memory units, such as a magnetic drum or magnetic core, all alternate routines are electronically selected. From feedback type of information, the computer can switch into and out of thousands of lengthy routines every second, sometimes repeating routines, other times completing only portions of routines or deleting routines.

We have many computer programs that contain several thousand steps stored in the computer at one time. Information is fed into the computer at high speed from punched cards or tape. Each card or section of tape entering the computer may represent different conditions which cause the computer to select the specific routine or combination that is tailored to the condition at hand. Thus, the computer could jump in and out of thousands of lengthy routines every minute, and it is conceivable that no two cases being fed into the computer would use the same identical routine.

We would like to make one thing absolutely clear. A computer has a big memory and can operate at tremendous speeds. But, contradictory to many glamour articles written about it, it has no brain. It is stupid. It has no will, no imagination or powers of reasoning. It is only as clever as the person creating the program of instructions. However, once the instructions are supplied in the form of a stored program they will be performed at tremendous speed with absolute discipline, no matter how complex or lengthy the program.

In stripping the mystery of intelligence from a computer. We do not want to underrate its capabilities.

Programs can be designed to cause the computer to benefit from its own experiences. Hundreds of alternate moves can be built into a computer program and the computer can test each alternate until the most suitable step is found. The program can provide for automatically making the best step part of the normal routine and discarding all of the other steps.

INFORMATION PROCESSING

The final reason for storing information is for the purpose of processing information. By that, we mean working on the information some way such as sorting, classifying, correlating or calculating.

A simple form of sorting is the method employed in mechanically sorting punched tabulating cards into different pockets, to extract certain conditions or to bring like conditions together. This can be done at the fairly high rate of speed of up to 1000 cards per minute.

With the advent of electronic computers, there are some new ways to organize or sort information. A magnetic disk or juke box type of system can store millions of digits of information. The big memory can be blocked off into theoretical pigeon holes that represent thousands of categories. Information can be fed into the memory system in random sequence and be electronically stored in its proper pigeon hole. It is in effect a way of sorting.

Magnetic drum or core memories can sort information internally at electronic speeds, that is, up to the limit of their storage capacity. However, the average drum or core memory cannot hold more than 40,000 digits of information at one time. Therefore, some large sorting jobs containing hundreds of thousands of digits of information cannot fit into a computer memory to be sorted, and must be done piecemeal or by slower methods.

A computer does its most fantastic job in calculation and correlation of information.

Every mathematical formula, no matter how complicated, can be stored as a program. Some computers can chase through every step in a fraction of a second.

Our computer programs cover a number of jobs that require thousands or tens of thousands of calculations such as budget calculations, invoicing, profit forecasts and payroll.

Our mill and a number of other steel mills are using computers to correlate a great deal of data on open hearths and blast furnaces. The data are relative to charges, practices and process control and are being correlated to determine the patterns that will give better yields and lower operating costs.

We are currently developing computer programs for faster and better production scheduling information. After storing a wide assortment of standard yield factors, the computer will calculate the exact quantity required at each operation for each order. It will display the detail status of each order, it will indicate which orders should be scheduled tomorrow, it will automatically balance out each order for favorable or unfavorable yields occurring in the system. It will simultaneously collect many statistics such as a projection of the total work load ahead of each operation for succeeding weeks, and will classify the total order pattern into customer and product categories.

We have talked about storing information for the purpose of repeating information, communicating information, controlling equipment and processing information. From various combinations of these four categories, new uses will evolve that may well be the most important developments in our lifetime. These uses will occur in some very unusual places, in fields that are as widely unrelated as finance, spaceflight and religion. Computers and other forms of electronic data processing were recently used successfully in making a concordance of the Bible and interpreting the Dead Sea scrolls.

There are a wide variety of electronic data processing tools available for jobs that range from simple problems to huge astronomical problems.

Discussion

PRESENTED BY

WILLIAM WARGO,
Superintendent Cold Strip Mill, Ford Motor Co.,Dearborn, Mich.

W. K. SMITH, Staff Systems and Procedures, Controller's Office, Steel Div., Ford Motor Co., Dearborn, Mich.

WILLIAM SCHARFENAKER,
Chief Ceramic Engineer, National Steel Corp., Detroit, Mich.

A. DONALD SHATTUCK, Superintendent Coke Plant, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

RICHARD M. PROBST,
Hanna Zabriskie & Daron, Detroit, Mich.

RICHARD ROWE, Allis/Chalmers Manufacturing Co., Detroit, Mich.

William Wargo: What happens when the tape breaks? Can the tape be spliced?

W. K. Smith: The tape that is normally used in most of the computers today is a special type of tape called mylar tape. It is not very susceptible to breaking. There are very few times we experience any breakage of tape. They can be spliced.

William Wargo: Since the bits on the tape are extremely close together, would you lose any bits after a splice?

W. K. Smith: Even though a splice could cause a gap between the magnetic bits, information is not normally lost. In an isolated case something could conceivably be lost but the computer could be programmed to signal this condition to the operator for corrective action.

William Scharfenaker: This subject sounds complicated. Where do you find the necessary people? What kind of people does it take to operate these units? It sounds like you need somebody who understands the vastly complicated electronic computers. Where do you find this sort of person in the steel mill organization? Can you train them? Are they college graduates who are highly trained people, or trained high school people? What is the source of technicians for maintenance?

W. K. Smith: It depends upon the nature of your problem. There are two major fields in electronic com-

puting. One is for scientific research and one is for business and commercial type applications. In each of those two fields it requires an entirely different type of skill.

William Scharfenaker: I am thinking particularly of the things that might apply to a steel mill operation.

W. K. Smith: Like a blooming mill operation, for example?

William Scharfenaker: Payroll matters, budget forecasts and orders that would apply to steel operations.

W. K. Smith: It takes a type of person that has an inventive mind, and there are usually some people in an office that have that ability. It also should be somebody that has a lot of experience with your own business. In our case we did not have to go outside to get anybody; we took people that had those combinations of talents and taught them how to program a computer and they create these jobs.

In the actual running of the computer, or what is called the console operation of the computer or button pushing part, it does not take any particular skill. We have trained people in two or three days to do that. The big job is in creating the program, which can sometimes consist of 1000, 2000 or 3000 steps that have to be set down in exact sequence. It takes us an average of about three months to develop a program. It does not require a Ph.D. degree but just someone who has some good solid thinking ability and is industrious. A background in the use of punched card tabulating equipment is also very useful to someone developing computer programming.

A. Donald Shattuck: If you have cards handled by many hands, what experience have you had with wearing out of cards? What is the life of the card system? What material do you use in making your cards?

W. K. Smith: We do not have any cards that are circulated in our mill except stores requisitions. All the cards that control our inventories are maintained in one central spot. When we first started, we had the wirephoto business that we now use at the shipping docks, hook up broadcast information from each production point into this central office until we could track down all the errors. This eliminated the necessity of having cards circulate in the mills which would have been objectionable in our particular circumstance but not necessarily so under other situations.

I think the man who is the procedure expert at your plant is planning some system that will result in cards being circulated in the mill; I want to learn from his experience how that works.

Richard M. Probst: The layman can understand by looking at a card of the type used by some banks and companies how the cards would be punched. The different items could be segregated by running the cards through an IBM machine or one of the other machines. When you have a tape, I gather it is a metal tape, do you magnetize that tape in certain areas which will in turn be picked up by the electronic machine? Will you explain the actual mechanics of it?

W. K. Smith: I am not an electronic engineer so I cannot give you much technical detail, but generally speaking it is just like a sound tape recorder that you may have at home. The sound tape recorder converts sound to impulses which in turn activate electromagnets. The electromagnets magnetize the tape in different spots as the tape is transported past the magnet.

Richard M. Probst: Does that make a rough surface?

W. K. Smith: No, the magnetic spots have no physical effect on the surface of the tape. When the tape is played back, the magnetic image on the tape can be converted back to pulses to operate a speaker to produce sound. Now a computer tape is just about the same thing. Data are converted to pulses in one of many different ways, and those pulses form invisible magnetic spots. The data tape can be played back to recreate the data that were originally recorded.

Richard M. Probst: Is it a metal tape?

W. K. Smith: It can be a metal base, coated with an iron oxide, but the type most frequently used now, is a plastic style tape called a mylar tape.

William Scharfenaker: Is that iron oxide impregnated in the plastic?

W. K. Smith: It is coated on the plastic. Incidentally, I suppose you know they are even using tape to record television programs now instead of the kinescope business they used to have, so that a television program can be played back instantly from the tape without any developing process. All these work the same way, the sound, the data, and now the television tape.

Richard Rowe: In reading about some of these computers they mention they frequently will go back and check your own calculations from time-to-time to be sure they are operating correctly. What happens in this case and how do you check to see whether it is sorting the information you give properly, or feeding back the item you put in, or is it infallible?

W. K. Smith: The computer checks itself as to whether it lost any information. There are built in, internal check circuits that do this. It is a technical point, and I cannot answer it specifically as to how the circuitry is engineered, but it is not necessary to check calculations, it is only necessary to check that the computer retains everything that is put into it. This is done by programming and by the built-in circuitry. We made millions, possibly billions of calculations on our electronic computers and never experienced one single error in calcultaion—therefore, I think it is unnecessary to go back and make spot check calculations from time to time or to do any other kind of duplicate or parallel checking of calculations.

Richard Rowe: What I am getting at is, if you put a specification in it you want it to repeat, how do you know it will repeat it verbatim?

W. K. Smith: With computers, it will come out exactly the same way you put it in because computers have internal checking circuits. There are a lot of other electronic data processing devices beside computers, some of which have checking devices and other do not. Therefore, other devices may not be completely infallible if they do not have internal checking circuits.

I would like to elaborate on the point raised a while ago. I said we trained all our own men. Of course we obtained a lot of help from the manufacturers of these

computers. They conduct schools of about a 2-week or 3-week period to provide the fundamentals of computer programming. That gets you over about five per cent of it and for the other 95 per cent of it you are on your own.

William Scharfenaker: One point you did not cover in my question, the matter of maintenance people. Particularly I think back to the time when I was in the Navy, and some people taught me how to operate radar equipment, but if it every broke down I was done. What happens in that case with this equipment? You teach people how to operate it, but how about maintenance?

W. K. Smith: We do not have to worry about that part at all. Most of the big computers, I think all of the big computers, can either be rented or purchased, and most people rent them. With the rental goes a maintenance contract, and the manufacturer maintains them for you free. They have a good staff of technicians that are on call day and night. We have called them out of bed several times at 2:00 am, and they have responded quickly. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, October 26, 1959—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Recent Developments in Air Traffic Control to Insure Greater Safety in Air Travel," by Paul Robinson, Chief of Air-Route Traffic Control Section, Federal Aviation Agency, Washington, D. C.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, October 13, 1959—Inspection Trip 4:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Inspection Trip: Dunkirk Works, Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

"Processing of Tool Steels," by W. H. Love, Chief Works Metallurgist, Dunkirk Works, Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

Dinner and Meeting, Shorewood Country Club, Dunkirk, N. Y.

CANTON SECTION

Monday, October 19, 1959—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Subject and Speaker to be announced later

Mergus Restaurant, Canton, Ohio

CHICAGO SECTION

No October Meeting

CLEVELAND SECTION

Tuesday, October 27, 1959—Dinner 6:30 P.M., Meeting 7:45 P.M.

Subject and Speaker to be announced later

Cleveland Engineering and Scientific Center, 3100 Chester Ave., Cleveland, Ohio

DETROIT SECTION

Tuesday, October 13, 1959—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Maintenance Symposium on Mechanical Equipment for: (1) Blast Furnace and Sinter Plants; (2) Open Hearths and Soaking Pits; (3) Blooming Mill Slab Shears and Scarfers; (4) Slab Heaters and Hot Strip Mills; (5) Pickling Lines and Cold Finishing Mills; (6) Annealing Furnaces and Continuous Lines.

Engineering Society of Detroit, 100 Farnsworth, Detroit, Mich.

LOS ANGELES SECTION

Details not available

PHILADELPHIA SECTION

No October Meeting

PITTSBURGH SECTION

No October Meeting

ST. LOUIS SECTION

Wednesday, October 28, 1959—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Panel Discussion on Electrical Maintenance. Moderator, Jean Scohy, Westinghouse Electric Corp., St. Louis, Mo.

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

No October Meeting

UTAH SECTION

Monday, October 12, 1959—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

Subject and Speaker to be announced later

Grand View Cafe, Provo, Utah

YOUNGSTOWN SECTION

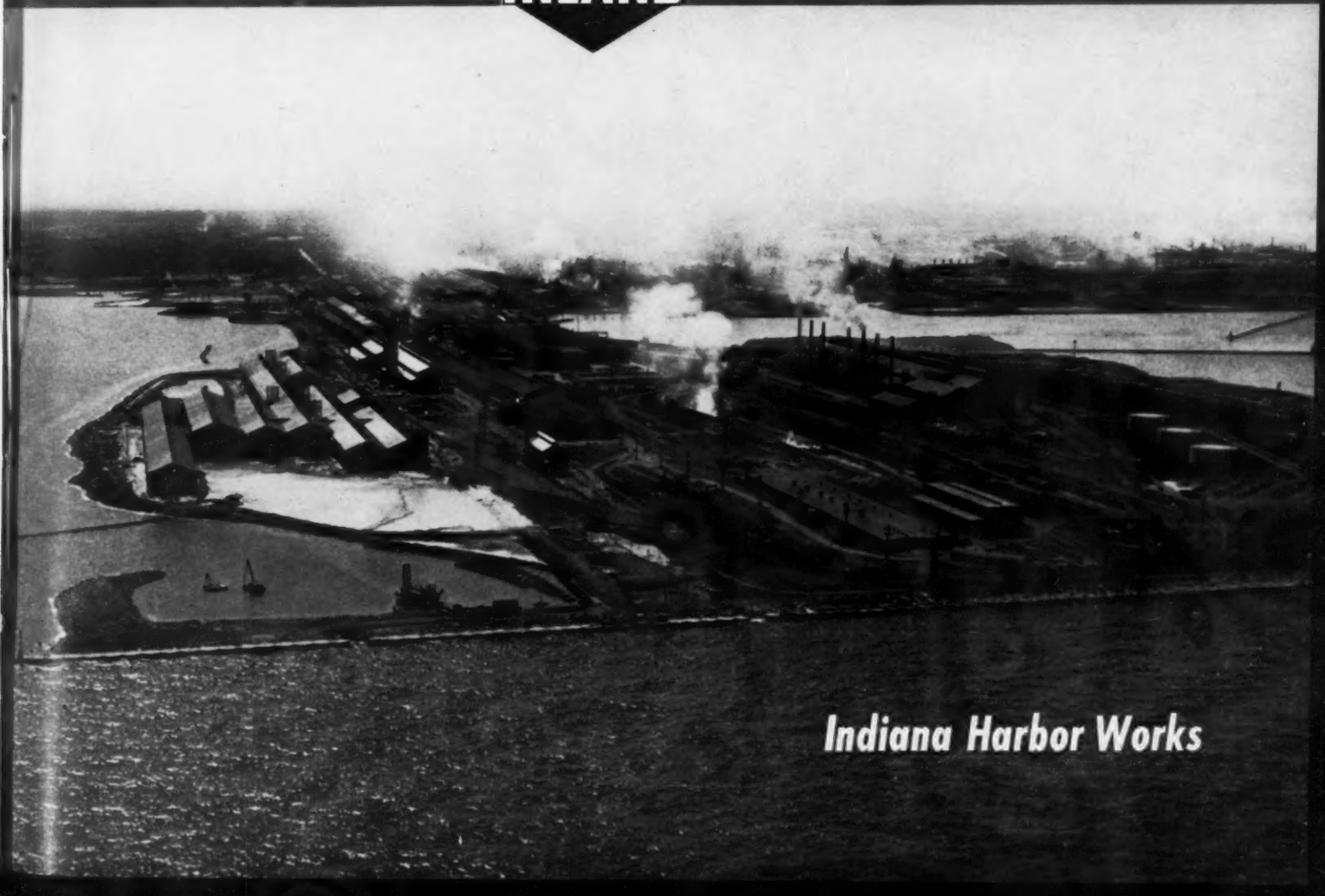
Monday, October, 26, 1959—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Electro-Mechanical Drives Under 500-HP for Steel Mill Applications" by Frank A. Woodbury, Consultant and Application Engineer, Westinghouse Electric Corp., Cleveland, Ohio

Mahoning Country Club, Girard, Ohio

INLAND STEEL COMPANY

INLAND

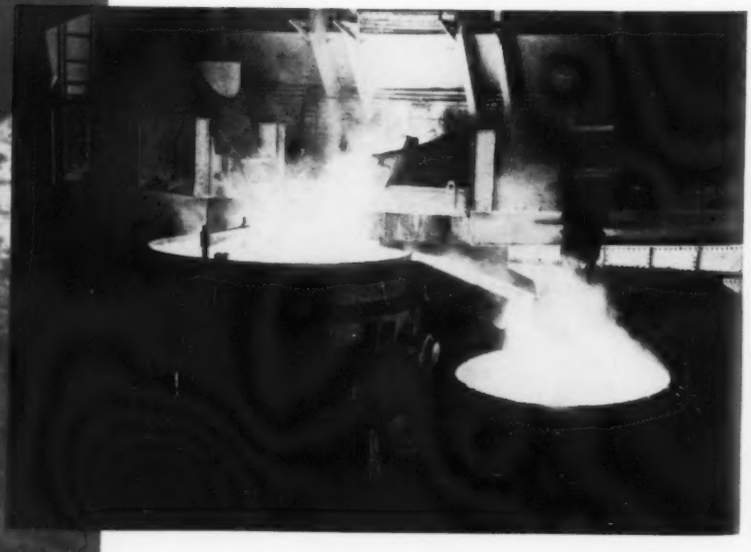


Indiana Harbor Works

INLAND STEEL COMPANY

Indiana Harbor Works

by T. J. Ess



JOSEPH L. BLOCK
Chairman

PHILIP D. BLOCK, JR.
Vice Chairman

FOR many years, Inland Steel Co. has enjoyed a distinction which is envied by the steel industry at large. Inland has consistently operated at rates well above the average rate for the industry. This fact, coupled with accessibility of raw materials and proximity of a large steel consuming market, has contributed heavily to financial well-being. To this, add progressive, service-minded management and there results the success that is Inland's today.

Probably the most optimistic of the eight young men who started a small rolling mill at Chicago Heights in 1893 could not then look ahead to its growth to seventh position in the industry's capacity. But the 66 years elapsed since have brought just that.

The original plant began by rolling some 5600 tons of bars a year on an old engine-powered, belt-driven hand mill. Soon after the venture started, it was decided to expand, and in 1902 steel was made in a new plant on the shore of Lake Michigan about 20 miles southeast of Chicago. This plant consisted of four open hearth furnaces, a blooming mill, a bar mill, eight sheet mills and a jobbing mill. The original ingot capacity of 85,000 tons per year grew to 620,000 tons per year by 1914, 1,575,000 tons by 1924, 1,965,000 tons by 1934, 3,400,000 tons by 1944, 4,700,000 tons by 1954 and 6,500,000 tons today. The company's employees rose from 1386 in 1904 to 29,000 today.

Inland now has 531 by-product coke ovens, eight blast furnaces, 43 open hearth furnaces, four blooming mills, two billet mills, two hot strip mills, cold strip finishing facilities, a structural mill, three bar mills and a sheared plate mill. This is the Indiana Harbor Works, all located on a site of about 1000 acres, with rights to fill in another 500 acres of lake area.

LEIGH B. BLOCK
Vice President
Purchasing

JOHN F. SMITH, JR.
President

FRANCIS M. RICH
Vice President
Steel Manufacturing

HJALMAR W. JOHNSON
Vice President
Research and Development

AERIAL VIEW OF INDIANA HARBOR WORKS

1. **Plant No. 1. Plant No. 3 is to the left of Plant No. 1 and not shown in this photo. All property to the right of the railroad tracks is Plant No. 2.**
2. **Indiana Harbor Canal.**
3. **Portion of plant of Youngstown Sheet & Tube Co.**
4. **Blast furnaces and coke plant of Plant No. 2.**
5. **No. 2 open hearth shop.**
6. **No. 2 blooming mill, structural mill and merchant mills.**
7. **Hot strip mills and No. 3 blooming mill.**
8. **Cold strip finishing.**
9. **No. 3 open hearth shop.**
10. **No. 4 blooming-slabbing mill.**
11. **No. 3 cold strip mill.**

In addition, Inland still operates the Chicago Heights plant. The original mill of 1893 has been rebuilt and modified over the years.

The Harbor Works forms a peninsula jutting out into Lake Michigan. It is divided into three adjacent plants, No. 2, No. 1 and No. 3, lying in that order from north to south.

No. 1 plant, the original site, now consists of No. 1 open hearth shop, No. 1 bloomer, two billet mills, a 100-in. sheared plate mill, a 24-in. bar mill, and strip galvanizing facilities.

No. 2 plant has five batteries of coke ovens with by-product and benzol units, six blast furnaces, two sinter plants, No. 2 and 3 open hearth shops, No. 2, 3 and 4 blooming mills, a 28-in. structural mill with 44-in. wide flange finishing stands, 14 and 10-in. merchant mills, 76 and 44-in. hot strip mills, and cold reduction, finishing and tin plating equipment.

One of Inland's fleet of ore carriers, the Wilfred Sykes, is shown here at the Great Northern ore dock.

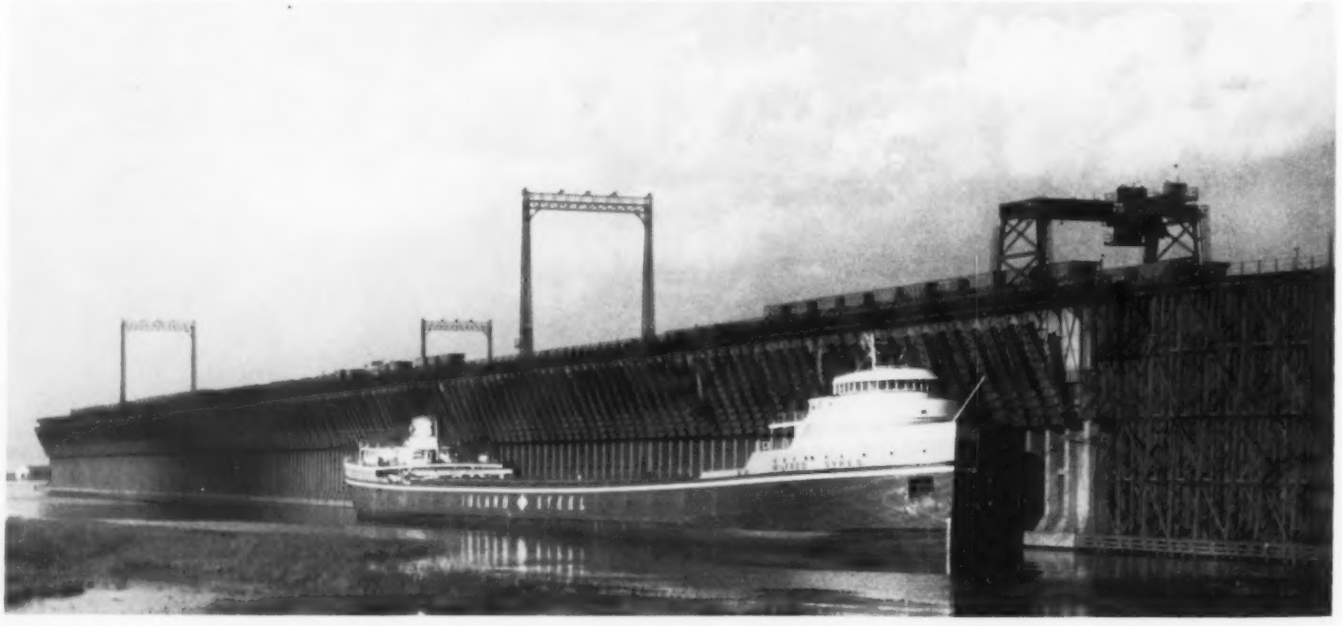


TABLE I
Iron Ore Analyses, Per Cent

Ore	Range	SiO_2	Al_2O_3	Bases	Fe	P	Mn
Leslie	Mesabi	10.18	2.32	0.26	49.28	0.092	0.87
Billie	Mesabi	11.26	0.81	0.36	53.53	0.066	0.55
Berner	Mesabi	5.97	1.34	0.26	51.68	0.086	0.80
Belden	Marquette	9.92	2.56	1.02	52.34	0.071	0.31
Sherwood	Menominee	6.13	2.46	2.91	51.12	0.415	0.83
Marmion	Atikokan	4.92	1.47	0.25	53.20	0.028	0.27
Reserve pellets	Mesabi	8.09	0.40	0.25	63.55	0.022	0.24
Marquette pellets	Marquette	8.85	0.79	0.53	61.47	0.033	0.05
Algoma Sinter	Michipicoten	11.79	1.73	11.53	49.50	0.020	2.84

No. 3 plant has two batteries of coke ovens with by-product and benzol plants and two blast furnaces. No. 3 plant was built during World War II for the Defense Plant Corp. and was subsequently purchased by Inland.

The main line of the Pennsylvania Railroad runs between No. 1 and No. 3 plants. Plants No. 1 and 2 are separated by the tracks of the Baltimore and Ohio, the New York Central, the Indiana Harbor Belt Line and the Elgin, Joliet and Eastern railroads. Since all of these tracks are at grade level, tunnels have been built under them to provide rail connections and a roadway between the three plants.

This coal preparation plant processes coal from company-owned mines at Wheelwright in eastern Kentucky.

RAW MATERIALS

As might be expected from Inland's location, all iron ore comes from the Lakes region and is brought in lake carriers up the Indiana Harbor Canal which borders the west side of the plant. Table I gives analyses of the ores now used.

The Billie ore is screened to plus $\frac{1}{8}$ in. Reserve pellets are beneficiated by magnetic separation and sintered before shipment. Marquette pellets are beneficiated by flotation and sintered before shipment. Algoma sinter is beneficiated using heavy-media separation and is also sintered before shipment.

In Plant No. 2, ore is unloaded and placed directly in storage by five 20-ton bridges. The storage yard is 3306

Limestone is loaded on lake carriers at Port Inland, about seven miles from the company-owned quarry at Manistique, Mich.

TABLE II
Coal Analyses, Per Cent

Kind	Source	Moisture	Volatile	Fixed carbon	Ash	Sulphur
Jewell Ridge Pocahontas	Virginia	4.77	21.96	73.21	4.83	0.67
Elkhorn	Kentucky	5.83	37.78	57.94	4.28	0.92
Wyoming Pocahontas	West Virginia	4.85	22.84	74.09	3.07	0.52
Bishop	West Virginia	5.84	22.40	72.05	5.55	0.58
No. 6 Seam	Illinois	9.17	37.31	55.49	7.20	0.95

ft long x 306 ft wide and will accommodate 2,650,000 tons of ore and stone. The same bridges reclaim ore from storage and dump it into the ore transfer car operating on the furnace high line.

Ore for Plant No. 3 is placed in a trough by two 12½-ton unloaders and is moved to storage by two 12½-ton retrievers, which also reclaim ore for the high line. This storage is 950 ft long x 484 ft wide and holds 1,045,000 tons of ore and stone.

All ore is screened to plus ¼ in. with the fines going to the sinter plant. There are three sintering lines of the continuous traveling grate type, with the following characteristics:

	No. 1	No. 2	No. 3
Length, ft	69	102	168
Grate width, ft	6	6	8
No. of windboxes	10	16	21
Fan capacity, cfm	100,000	150,000	440,000
Suction, in. of water	10–14	10–18	35
Capacity, tons per day	764	1224	4000

The sinter feed consists of varying amounts of Leslie, Sherwood, Berner and Marmion fines, flue dust, filter coke, mill scale and limestone fines. With Sherwood and Leslie ores, screened ore and sinter analyze as follows;

	Screened ore, per cent	Sinter, per cent
SiO_2	7.91	10.08
Al_2O_3	2.40	2.51
Bases	1.74	9.37
Fe	50.31	53.18
P	0.272	0.154
Mn	0.64	0.63

The daily consumption of ore and sinter for both plants runs about 16,500 tons. No. 3 sinter line was put in operation only recently and its effect does not show in the figures given in this article.

Coal comes from company-owned mines at Wheelwright in eastern Kentucky and from purchases of West Virginia, Virginia and Illinois coals. Typical analyses are shown in Table II.

The West Virginia and Virginia coals are washed at the mines. The minus ¾ in. is used in the coking blend. Kentucky coals are also washed at the mines and graded to a size of minus 2½ in. Illinois coal is washed and double screened to minus 2 in., plus ¾ in.

At No. 2 plant, coal is received by boat during the shipping season. It is unloaded by two 17-ton bridges and carried to storage by a 600-ton-per-hr belt conveyor. During the winter, coal is brought in by rail, dumped into a track hopper and moved to storage by the same conveyor. Storage capacity is 300,000 tons, from which coal is reclaimed by three 6-ton bridges.

At No. 3 plant, all coal comes in by rail, is dumped into a track hopper and is taken by belt conveyor to a junction building from where the coal may be moved to the breaker building or to a storage area of 100,000-ton capacity. Two 6-ton bridges reclaim coal from this storage.

Coal used by the coke ovens averages about 7800 tons per day for Plant No. 2, 3400 tons per day for Plant No. 3, or 11,200 tons per day total.

Limestone for the blast furnaces and open hearths comes from the company-owned Inland Lime and Stone Co. at Manistique, Mich.

The stone, which is crushed and screened to plus 4 in., minus 6 in. at the quarry, averages about as follows:

	Per cent
SiO_2	2.38
R_2O_3	0.90
CaO	52.30
MgO	1.55
S	0.033
CO_2	42.75
H_2O	0.19

Most of the stone is dumped directly into the storage yards by self-unloading boats. The remainder is unloaded, stored and reclaimed in the same way as ore. Some additional storage for stone is obtained by tying

Seven batteries of by-product coke ovens give the Harbor Works capacity to produce 2,847,000 net tons of coke per year.

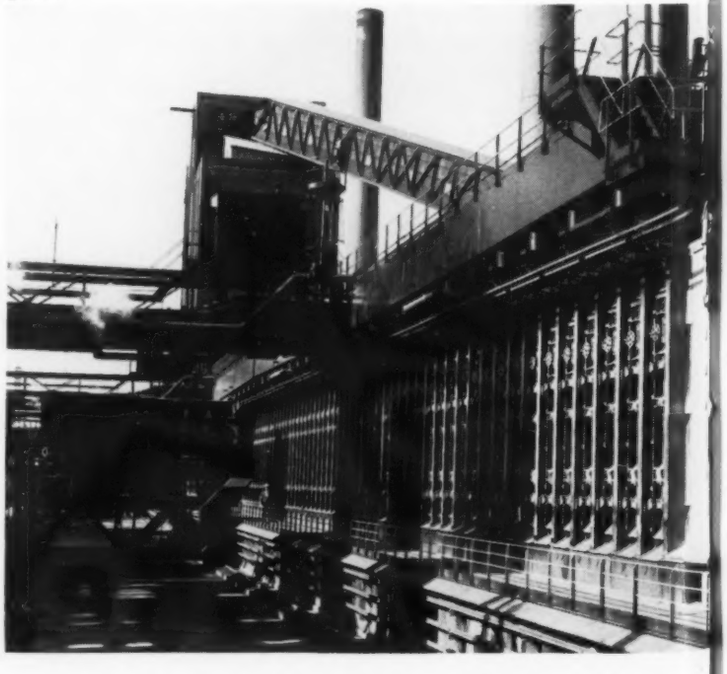


TABLE III
Coke Ovens

	Plant No. 2					Plant No. 3	
Battery No.	2	6	7	8	9	A	B
No. of ovens	59	65	87	87	87	73	73
Oven width, pusher side, in.	17	16¾	16¾	16¾	16¾	16¾	16¾
Oven width, coke side, in.	19½	19¾	19¾	19¾	19¾	19¾	19¾
Oven length, inside, ft-in.	37-7	37-7	37-7	37-7	37-7	40-5⅝	40-5⅝
Oven height, ft-in.	12-0	12-0	12-0	12-0	12-0	12-0	12-0
Coal charge, tons per oven	16¼	16¼	16¼	16¼	16¼	17¼	17¼

up four ore boats full of stone along the docks at the close of the shipping season. The stone is unloaded periodically during the winter so the boats are empty by the start of the next shipping season.

Daily limestone consumption is about 3600 tons.

COKE PLANTS

Seven batteries of by-product coke ovens, totaling 531 ovens, provide capacity for making 2,847,000 net tons of coke per year. Five batteries (385 ovens) are located in Plant No. 2, two batteries (146 ovens) in Plant No. 3. Table III gives some pertinent data on the ovens. Batteries Nos. 2, 8 and 9 are low differential combination gun flue type; all others are underjet. All ovens are heated with coke oven gas.

At Plant No. 2, coal is reclaimed from storage by the bridges, dropped into a bridge hopper, then to a transfer car which carries the coal to the track hopper. Conveyors then move the coal to the crusher house. Three breakers provide capacity to crush 600 tons of coal per hr, which is then further reduced to 80 to 90 per cent through a ⅛-in. mesh by four hammer mills. Twin conveyors then move the coal to the mixer building. Here three automatic scale-controlled conveyors move the various grades of coal to the mixer in the desired proportions. The coal mixture is then conveyed to a junction house where it is again mixed before moving to the oven storage bins. The usual mixture is 55 per cent high volatile coal, 45 per cent low volatile, giving a charge of about 29.45 per cent volatile matter, 65.84 per cent fixed carbon, 4.71 per cent ash, 0.78 per cent sulphur, and 5.41 per cent moisture.

With normal operation, 486 ovens are pushed per day, giving a gross coking time of 19 hr per oven. This schedule can be increased to 522 ovens per day, or 17.7 hr per oven.

Coke from the ovens of the five batteries is pushed into 14-ton quenching cars and taken to one of three brick quenching towers. It is then dumped on one of two brick-paved wharves. After cooling, it is conveyed to the screening station. The minus 1-in. coke goes to a domestic screening station where it is sized to minus 1 in. x plus ⅝ in. domestic coke and minus ⅝ in. breeze. The plus 1 in. coke is conveyed to the blast furnaces.

At Plant No. 3, coal may be reclaimed from storage by bridge or brought directly from the track hopper. In either case, it is handled entirely by conveyors. In the crusher building, coal is first reduced to about 1½ in. by two breakers, each of 250-ton per hr capacity. It is then ground in two 250-ton per hr hammer mills so that 80 to 90 per cent will pass through a ⅛-in. mesh. The coal is mixed by weight under the control of conveyor scales and taken to the battery storage bins. In this plant the coal mix is generally 50 per cent high volatile coal and 50 per cent low volatile. This mixture gives a charge of 30.35 per cent volatile matter, 65.34 per cent fixed carbon, 4.31 per cent ash, 0.73 per cent sulphur and 5.80 per cent moisture.

No. 3 plant usually operates at a rate of 198 ovens pushed per day, for a gross coking time of 17.7 hr per oven.

Coke pushed from the ovens is handled in the same manner as in Plant No. 2, except that the screening station is located on the blast furnace highline, to which the run-of-oven coke is conveyed on a 36-in. belt.

Coke from both plants contains 0.55 to 0.65 per cent volatile, 93 to 94 per cent fixed carbon, 5.5 to 6.5 per cent ash, about 0.65 sulphur and 5.0 to 6.5 per cent moisture.

By-product recovery is accomplished by conventional equipment at both coke plants. Tar and liquor from the batteries are separated from gas in downcomers ahead of primary coolers. Separation of tar and liquor is made in decanting tanks, with the tar going to storage and the liquor being processed in an ammonia still and a phenol recovery plant. Phenolate goes to storage and ammonia is put back into the gas stream.

The gas goes through conventional direct-contact

General view of coal chemicals area of the coke plant in Plant No. 3. Blast furnaces are in the background.

primary coolers, exhausters, precipitators, ammonia absorbers, final coolers and scrubbers.

Light oils are absorbed in gas scrubbers (six at No. 2 plant, two at No. 3 plant) and then recovered from the absorbent oil by steam distillation. After removing the forerunnings in continuous CS_2 distillation columns, the light oil is washed with 66-degree Baumé sulphuric acid and neutralized with caustic soda. Separation of the benzol is then performed in continuous motor fuel columns. The bottoms from the benzol column are processed in batch stills to recover toluol and xylol.

At both coke plants, yields are about as follows:

Per cent furnace coke	67–68
Per cent domestic coke	1.0–1.2
Per cent breeze	2.7–3.2
Cu ft of gas per ton of coal	10,600
Gal of tar per ton of coal	7.4–7.7
Gal of light oil per ton of coal	2.7–3.0
Lb of ammonium sulphate per ton of coal	20.2–21.8

Approximately 40 per cent of the gas made is used to underfire the ovens. The surplus at each plant flows through a 50,000-cu ft gas holder and is then boosted to 4 to 6 psi pressure and put into the general gas lines to the mills.

When the surplus coke gas supply is insufficient to meet the plant demand, it is supplemented with natural gas mixed with enough air (about five parts gas, three parts air) to give a calorific value of 570 Btu per cu ft.

BLAST FURNACES

Inland's iron is produced in eight blast furnaces with a combined capacity of 3,325,000 net tons per year. Six of these form a row in Plant No. 2. Two furnaces are in Plant No. 3. Some characteristics of these furnaces are given in Table IV.

The hearths of all furnaces are cooled by cast steel staves. Conventional bronze cooling plates are carried up through the crucible walls, and up through the bosh on all furnaces except B, which has channel cooling on the bosh. Channels are combined with plates on the boshes of No. 2 and 4 furnaces. No cooling plates are used above the mantles except on No. 2 furnace, where seven rows are installed. Cast steel wearing plates built into the brickwork provide stockline protection in all furnaces.

Carbon is used in the linings of four furnaces to the following extent:

No. 2 furnace—79½-in. carbon bottom. Sidewalls 27 to 22½ in. thick to 1 ft-3 9/16 in. above the tuyere centerlines.

No. 3 furnace—31½-in. thick sidewalls from 9 in. below the hearth staves to 15 in. above.

No. 4 furnace—79½-in. carbon bottom. Sidewalls 27 to 22½ in. thick up to 3⅜ in. above the tuyere centerlines.

B furnace—85½-in. carbon bottom. Sidewalls 31½ to 22½ in. thick up to 21 in. above the tuyere centerlines. Bosh walls 13½ in. thick to the mantle.

This view shows two of the six blast furnaces in Plant No. 2. Inland's eight furnaces provide an annual capacity of 3,325,000 tons of iron.

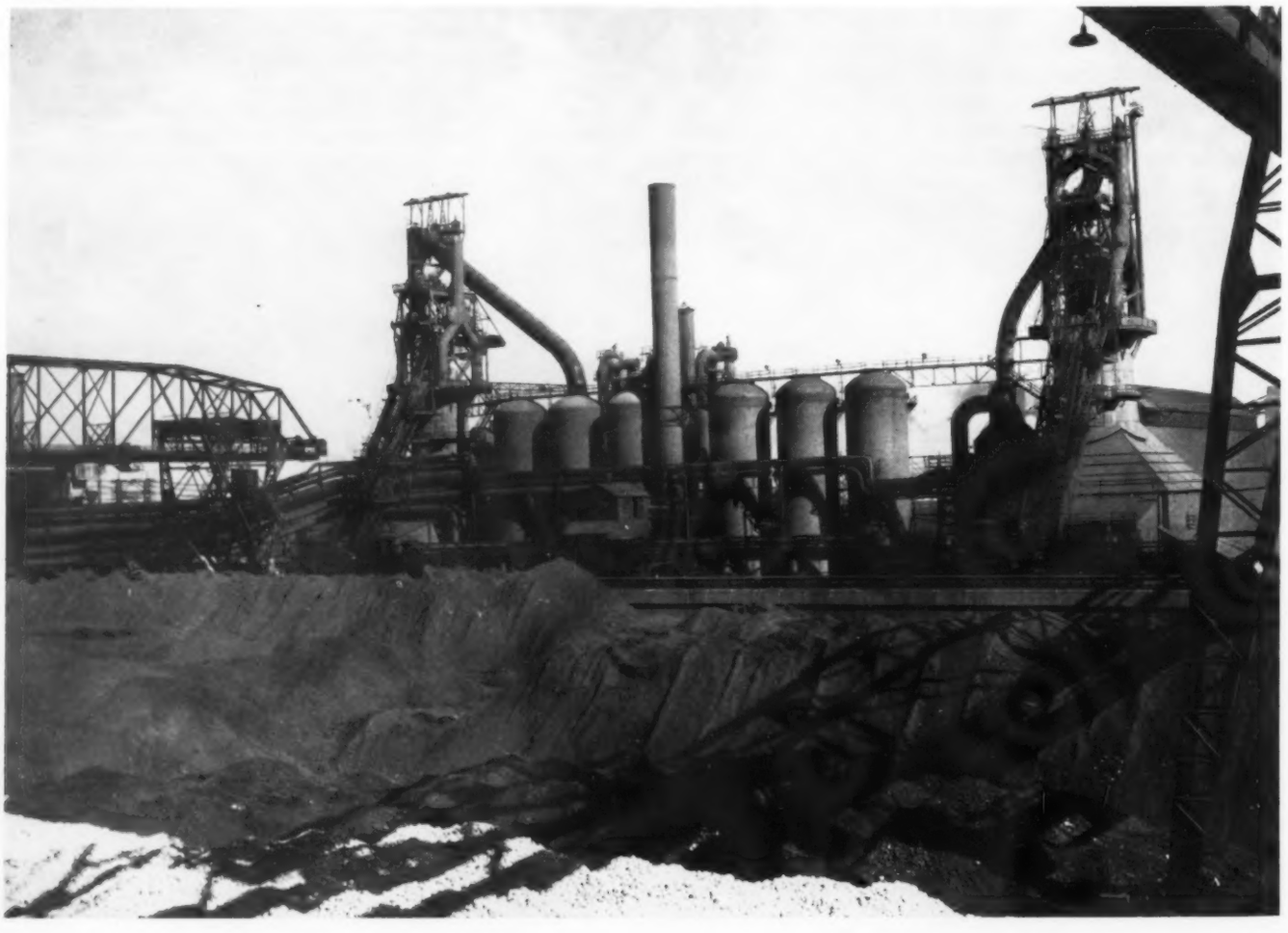


TABLE IV
Blast Furnace Data

	Plant No. 2						Plant No. 3	
Furnace	1	2	3	4	5	6	A	B
Diameter of hearth, ft-in.	20-0	19-9	17-3	20-9	25-9	25-9	25-9	26-6
Diameter of bosh, ft-in.	23-6	23-3	22-0	24-3	28-9	28-9	28-9	29-6
Diameter of stockline, ft-in.	17-6	17-6	16-6	18-6	20-0	20-0	20-0	20-9
Height, bottom to top ring, ft-in.	95-11	92-5 5/8	91-5 1/4	98-3	102-0	102-0	102-0	104-0
Height, iron notch to stockline ft-in.	74-0 1/8	69-9 1/4	67-4 3/8	74-11 3/4	82-11 1/4	82-11 1/4	82-11 1/4	82-11 1/2
Height of crucible, ft-in.	9-7	13-2 7/8	10-2 1/2	14-3	11-9	11-9	11-9	13-7 7/8
Height of bosh, ft-in.	11-0	11-0	13-9 3/8	11-0	10-0	10-0	10-0	10-0
Height of straight section, ft-in.	12-2 1/2	10-2 9/16	6-10 11/16	12-1 1/2	9-6	9-6	9-6	9-7 1/2
Height of inwall section, ft-in.	42-1 5/8	39-6 11/16	38-0 5/16	41-10 1/4	53-9	53-9	53-9	53-7
Height, stockline section to top ring, ft-in.	19-0 7/8	18-5 1/2	22-6 3/8	19-0 1/4	18-0 1/4	18-0 1/4	18-0 1/4	18-0
Height, bottom to iron notch, ft-in.	1-11	4-2 5/8	1-6 1/2	4-3	2-0	2-0	2-0	3-10 7/8
Height, iron notch to cinder notch, ft-in.	4-6	4-2	3-11 3/4	4-6	4-8	4-8	4-8	4-8
Height, cinder notch to tuyeres, ft-in.	3-4	3-4	3-0	3-4	3-4	3-4	3-4	3-4
Working volume, tuyeres to stockline, cu ft	24,922	22,666	20,225	26,985	39,411	39,411	39,411	41,762
Bosh angle, deg-min-sec	80-57-57	80-58-0	80-13-0	80-58-0	80-28-9	81-28-9	81-28-9	81-28-9
Inwall slope, in. per ft	0.854	0.872	0.868	0.824	0.977	0.977	0.977	0.980
No. of tuyeres	12	12	12	12	14	14	16	16
Tuyere diameter, in.	6	6	5 & 6	6	5 & 7	5 & 7	5, 6 & 7	5, 6 & 7
No. of columns	6 (Stl.)	8 (CI)	8 (CI)	8 (CI)	7 (Stl.)	7 (Stl.)	8 (Stl.)	8 (Stl.)
Lining thickness, crucible, in.	36	27	31 1/2	27	31 1/2	31 1/2	36	31 1/2
Lining thickness, bosh, in.	27	22 1/2	27	22 1/2	27	27	27	25 1/2
Lining thickness, stack, in.	28 1/2	33	40 1/2	33	45	45	45	40 1/2
Lining thickness, throat, in.	35	36	24 1/2	31 1/2	44	44	44	39 1/2
Big bell diameter, ft-in.	13-3	13-0	12-6	14-0	15-0	15-0	15-0	15-9
Big bell angle, deg.	53	50	50	53	53	53	53	53
Small bell diameter, ft-in.	5-6	5-6	4-8	5-6	6-6	6-6	6-6	6-6
No. of gas offtakes	4	4	4	4	4	4	4	4
Inside diameter of offtakes, ft-in.	4-0	3-10	3-6	3-10	4-9	4-9	4-9	4-9
No. of present lining	11	8	8	6	3	3	2	3
Date last blown in	10-30-53	9-7-57	9-15-56	7-25-58	3-12-52	8-7-56	2-17-55	9-23-58
No. of stoves	3	4*	3	4*	3	4*	3	3
Stove diameter, ft	24	24	24	25	26	26	26	26
Stove height, ft	100	100	93	105	110	110	110	110
Checker openings, in.	(1) 3 & 2	(1) 4 1/2 (F)** & 3 1/4	3 & 2	5 1/4 (F)	5 1/4 (F)	(2) 1 15/16	1 15/16	1 1 5/16
	(1) 3 1/2 & 1 1/2	(2) 3 & 2	...	...	...	(2) 3 1/2 & 1 1/2	...	...
	(1) 5 1/4 (F)	(1) 5 1/4 (F)	...	...	...	...	...	...
Heating surface per stove, sq ft	(1) 177,190	(1) 188,114	162,148	139,665	211,070	(2) 298,539	247,000	247,000
	(1) 227,982	(2) 177,221	...	...	...	(2) 247,115	...	...
	(1) 166,142	(1) 166,142	...	...	...	...	...	...
Blast volume, cfm, average	53,754	49,760	44,459	58,053	74,250	84,014	76,657	71,225
Blast volume, cfm, maximum	64,000	52,000	48,000	70,000	85,000	90,000	80,000	85,000
Blast temperature, F, average	1386	1136	1150	1229	1434	1308	1032	1196
Blast temperature, F, maximum	1400	1250	1300	1400	1500	1500	1500	1500
Blast pressure at tuyeres, psi	18.1	17.4	18.5	18.1	19.0	27.2	19.5	19.0
Lb of ore per net ton of iron	3501	3691	3773	3818	3873	3694	3597	3799
Lb of stone per net ton of iron	566	738	733	677	678	642	683	657
Lb of coke per net ton of iron, dry	1490	1701	1526	1611	1464	1492	1700	1684
Lb of scrap per net ton of iron	31	80	24	17	33	31	5	11
Lb of roll scale per net ton of iron	230	70	11	72	118	69	132	69
Daily iron production, avg. net tons	958	809	724	965	1391	1609	1300	1241
Daily iron production, max. net tons	1467	1053	1000	1453	1749	2016	1648	1653
Lb of slag made per ton of iron	847	912	913	899	864	838	881	904
Lb of flue dust made per ton of iron	190	151	213	143	169	191	173	231
Fuel ratio, burden to coke	2.40	2.11	2.26	2.53	2.43	2.57	2.29	2.34

* One stove on furnaces No. 2, 4 and 6 may be switched, respectively, to furnaces No. 1, 3 and 5.
** (F) Denotes use of fillers or inserts.

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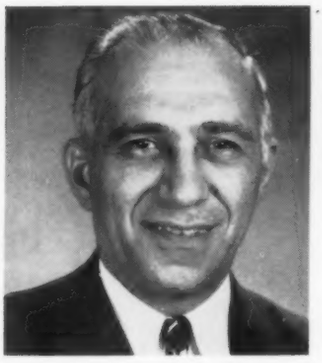
Asst. General Manager
Primary Production



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No. 6 furnace was converted to high top-pressure operation on its most recent reline, and it is planned to do the same on No. 5 furnace.

The six furnaces in Plant No. 2 are served by a continuous high line containing 63 ore bins of 125 to 200-ton capacity each, and 14 limestone bins of 80 to 100-ton capacity each. In addition, there are 10 bins used for nut coke. Coke bins on No. 1, 2 and 3 furnaces each have a 45-ton capacity. No. 4 bin is 90-ton capacity. No. 5 and 6 furnaces each have four 35-ton furnace coke bins.

At No. 3 Plant, furnaces A and B are served by eleven 125-ton ore bins, two 80-ton limestone bins and four 78-ton coke bins.

All furnaces are equipped with double skip hoists, motor-operated. Skip cars are of 110-cu ft capacity on No. 1, 2 and 3 furnaces, 180 cu ft on No. 4 furnace, and 196 cu ft on furnaces 5, 6, A and B. All skip cars dump into rotating distributor tops. Bells are operated by steam on No. 1, 2 and 3 furnaces, by motor on the others.

At Plant No. 2, the furnaces are blown by eight turbine-driven blowers, five rated at 60,000 cfm, 30 psi, two at 75,000 cfm, 30 psi and one at 125,000 cfm, 35 psi. A duplicate 125,000-cfm unit is now being installed.

Plant No. 3 has three 75,000-cfm, 30 psi blowers. All turbines are equipped with surface condensers. In both plants, the blowers can be cross-connected so that they may be used on various furnaces, furnishing protection against failure of any particular unit.

Blast for the furnaces is heated by the stoves listed in Table IV. All stoves are two-pass, side combustion units. Blast furnace gas is introduced through pressure type proportioning burners at a rate of 10,000 to 25,000 cfm. The stoves consume about 35 per cent of the total gas produced. Stove cycles are usually two hours on blast, four hours on gas. Stove stack temperatures range between 350 and 550 F.

Blast temperatures to the furnaces are automatically controlled by mixer valves.

Gas leaves the furnace tops through four offtakes, which combine into two uptakes and finally into a single downcomer on all furnaces except No. 3, which has two downcomers. Furnace top temperatures range between 310 and 365 F. Top pressures run 1.9 to 2.1 psi except on No. 6 furnace, where it is maintained at 10 psi.

Gas leaving the furnace tops generally contains 8 to 15 grains of dust per cu ft and has analyses somewhat as follows:

	Per cent
Co_2	12.7–15.0
CO	25–27
H_2	2–4

Its heating value ranges 93 to 103 Btu per cu ft.

All blast furnace gas passes through dust catchers, which reduce the dust content to 3.5 to 5.7 grains per cu ft. The most recent dust catchers are 30 ft in diameter and 40 ft high between bendlines.

All of the gas then passes through wet washers which lower the dust content to 0.11 to 0.26 grain per cu ft. Three furnaces have venturi type scrubbers which bring the dust content down to 0.02 to 0.04 grain per cu ft. The other five furnaces are equipped with 40,000-cfm disintegrators through which about 35 per cent of the gas is cleaned to 0.07 to 0.09 grain of dust per cu ft for the stoves.

In addition, furnaces A and B have electrostatic precipitators which bring dust content down to 0.001 to 0.005 grain per cu ft.

Surplus blast furnace gas is used to fire boilers and in the soaking pits.

Water from the wet washers flows to thickeners where the dust settles out of the water. At Plant No. 2 there are two thickeners 160 ft in diameter, each with a capacity of 16,000 gpm. At No. 3 plant, one 80-ft double tray unit has a capacity of 7000 gpm. The sludge from these units is taken to the sintering plant, where it is used in the sinter mix.

All furnaces usually produce basic iron of which practically all is used as hot metal in the open hearth furnances. Iron analyses normally fall in the following range:

	Per cent
Silicon	1.04–1.12
Sulphur	0.028–0.032
Phosphorus	0.201–0.292
Manganese	0.62–1.43

Iron is cast from each furnace every 4.8 hr into mixer-type ladles of 100 or 200-ton capacity, which are then shifted to the open hearth shops.

Only two to three per cent of the iron production—iron not meeting open hearth limits or some occasional

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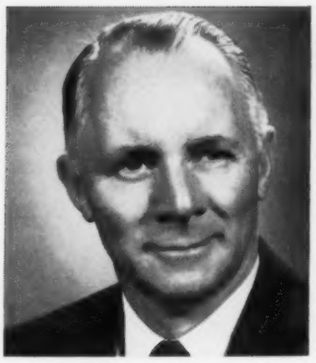

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Asst. General Manager
Community Relations

surplus above open hearth requirements—is pigged. Two double-strand pig machines provide 1750-ton-per-day capacity at Plant No. 2. One 2500-ton-per-day machine is installed at Plant No. 3.

Slag from the furnaces usually approximates the following analysis:

	Per cent
SiO_2	36.3
Al_2O_3	12.4
CaO and MgO	48.3
S	1.29
Fe	0.70
Mn	1.01

At Plant No. 2, slag is tapped into ladles and hauled to the dump. At No. 3 Plant, slag is run into granulating pits adjacent to the furnaces and subsequently dug out by power shovel. Most of the blast furnace slag is used for plant site fill.

STEELMAKING

Inland produces steel in 43 stationary basic open hearth furnaces located in three separate shops. No. 1 shop, which now contains twelve 108-ton furnaces, was the location of the original four 60-ton furnaces built in 1902. By 1913 this shop was expanded to 12 furnaces.

No. 2 shop, with 24 furnaces built between 1916 and 1939 in a single line, is the longest open hearth shop in the world.

General view of charging floor in No. 2 open hearth, which contains 24 furnaces in a single row.

General view of charging floor in No. 3 open hearth which was built in 1952 and expanded in 1957.

No. 3 shop went into operation in 1952 with four furnaces and three were added in 1957.

Table V gives principal proportions of all open hearth furnaces and buildings.

No. 1 shop—One furnace in this shop has basic ends. All other refractory construction is of conventional refractories. All of the furnaces here have bottoms about 33 in. thick at the center of the furnace.

This shop produces carbon steels in killed, semikilled and rimmed grades. Approximately 14 per cent of the product is of 0.10 per cent carbon or under, 62 per cent is 0.11 to 0.25 carbon, 22 per cent is 0.26 to 0.65 carbon and about 2 per cent above 0.65 carbon.

A normal charge weight is 255,000 lb. The metallic charge per net ton of ingots averages about 1233 lb total iron, 910 lb of scrap, 114 lb of ore and sinter and 22 lb of ferro alloys. Of the scrap, approximately 45 per cent is home scrap, 55 per cent purchased. About 160 lb of limestone is used per ton of ingots, plus about 22 lb of flux additions. Deoxidizers, principally 22 per cent ferro silicon and aluminum, run about 0.3 lb per ton.

Hot metal comes in mixer-type ladles from the blast furnaces at No. 3 Plant to a hot metal station near the middle of this shop. Here it is poured into hot metal ladles which are handled by 50-ton hot metal cranes in the lean-to. The ladle is placed on one of four hot metal cars which move across the charging floor to the furnace. Each car carries a hot metal spout and is designed with motor-operated tilting mechanism.

Cold materials are charged to the furnaces from 22-cu ft charging boxes handled by four overhead charging machines. Drags of charging cars are brought up an incline from the nearby scrap yard.

Fluxes and alloys are unloaded as received into bins along the back of the charging floor.

The furnaces in No. 1 shop are fired with bunker C fuel oil and natural gas through artillary type water-cooled burners. Total heat input is about 80 per cent from oil, 20 per cent from gas. Fuel input totals 60,000,000 Btu per hr maximum, 43,700,000 Btu per hr average.

Oil is received by pipeline direct from a nearby refinery. Oil is stored in two 500,000-gal storage tanks and five 100,000-gal tanks. It is automatically held at 200 F by a central heating station.

Each furnace is equipped with a forced draft fan of 12,000 to 16,000-cfm capacity. Eleven furnaces are equipped with meters and instruments to measure fuel oil, coke oven gas, natural gas, combustion air, checker temperatures, bath temperature and furnace pressure. Three of these furnaces have automatic reversing equipment. Six have fuel-air ratio control. One furnace is equipped for experimental firing with high pressure natural gas, and has Btu summarization, gas-oil ratio and fuel-air ratio control and automatic reversal. Fuel consumption averages 3,716,000 Btu per net ton of ingots.

Each furnace has a waste heat boiler and induced draft fan, producing about 13,000 lb of steam per hr. Waste gases then pass to 150-ft stacks.

The furnaces turn out heats in 8.11 hr per heat, charge-to-tap, or 9.14 hr per heat, tap-to-tap. This gives average production rates of 13.38 tons per hr net, 11.77 tons per hr gross. No oxygen is used in No. 1 shop for flame enrichment or for decarbonization.

Heats average 108.8 tons each. Steel is poured into

TABLE V
Open Hearth Data

Shop no.	1	2		3
Furnace size, tons	108	170	200	320
No. of each	12	10	14	7
Length inside buckstays, ft-in.	(4) 56-0; (8) 60-0	68-0	70-1	91-0
Width inside buckstays, ft-in.	17-3	19-9	22-0	25-7
Hearth length, ft-in.	33-6	43-6½	44-6	(3) 63-7½; (4) 66-0
Hearth width, ft-in.	13-3	15-0¾	17-0	(3) 18-6; (4) 15-10
Hearth area, sq ft	523	769	803	1248
Sq ft of hearth per ton	4.84	4.52	4.01	3.90
Bottom (at center of furnace)	½-in. insulation	3-in. chrome fill	3-in. chrome fill	3½-in. insulation
	9-in. firebrick	9-in. chrome-magnesite brick	9-in. chrome-magnesite brick	9-in. firebrick
	9-in. chrome brick	12-in. magnesia brick	12-in. magnesia brick	12-in. chrome brick
	15-in. rammed refractory	15-in. magnesia ramming mix	15-in. magnesia ramming mix	15-in. magnesia ramming mix
Front wall height, foreplate to skew, ft-in.	4-10	5-8	5-8	5-1½
No. of charging doors	(1) 5; (11) 3	5	5	(3) 5; (4) 7
Back wall	Sloping (4); straight (8)	Sloping	Sloping	Sloping
Height, foreplate to skew, ft-in.	4-5	4-6	4-6	5-1½
Roof	18-in. silica with 20-in. ribs	16-in. silica with 20-in. ribs	16-in. silica with 20-in. ribs	(6) 18-in. silica with 22½ in. ribs; (1) 12-in. basic with 15-in. ribs
Roof span, ft-in.	(4) 17-3; (8) 13-3	22-8¾	22-8¾	23-3⅞
Roof rise, in.	22	24	34	(6) 42; (1) 52
Roof length between knuckles, ft-in.	31-9 to 35-9	45-0	45-0	(3) 58-10; (4) 68-0⅝
Height, foreplate to roof at center, ft-in.	6-4	7-11	7-11	9-1½
Downtakes	(11) Double	Single	Single	(3) Double
Dimensions, ft-in.	5-0 × 4-8 and 5-4	16-9 × 3-8	16-9 × 3-8	6-3 × 8-8
Area, each end, sq ft	50	61.4	61.4	108
	(1) Single 14-3 × 3-0 42.75	...	...	(4) Single 18-6 × 3-9 69.4
Slag pockets, length, ft-in.	14-3	20-0	20-0	21-4½
Slag pockets width, ft-in.	(4) 11-2; (8) 12-3	14-5	14-5	18-5
Regenerators	(8) double, 17 ft-6 in. long × 22 ft-3 in. wide × 14 ft-3 in. deep	Single, 25 ft-3 in. long × 24 ft-1 in. wide × 22 ft-5¾ in. deep	Single, 25 ft-3 in. long × 24 ft-1 in. wide × 22 ft-3 in. deep	Single, (1) One-pass, 30 ft long × 25 ft wide × 27 ft
	(4) single, 19 ft long × 22 ft-6 in. wide × 14 ft-3 in. deep			(6) Two-pass, 30 ft to 41 ft-6 in. long × 25 ft wide × 27 ft high
Depth of checkerwork, ft-in.	9-4½	12-4½	11-3	(3) 16-6; (4) 16-1½
Checker volume, each end, cu ft	(8) 3652; (4) 4010			(3) 14, 014; (4) 10,100
Checker flues, in.	(6) 10½ × 6; (6) 7 × 9	10½ x 6	10½ x 6	(1st pass) 9½ x 9½ (2nd pass) 7½ x 7½
Flue size, furnace to stack	5 ft-9 in. x 4 ft-0 in.	4 ft-6 in. x 7 ft-7½ in.	4 ft-6 in. x 7 ft-7½ in.	(3) 8 ft-0 in. x 8 ft-6 in.; (4) 7 ft-0 in. x 7 ft-11 in.
Stockyard				
Length, ft-in.	715-0	(1) 863-0	(1) 882-0	644-0
Width, ft-in.	85-9	(1) 100-0	(1) 100-0	102-0
Cranes	(3) 10-ton	(4) 10-ton	(4) 15-ton	(3) 15-ton
Leanto				
Length, ft-in.	865-0	2150-0		504-0
Width, ft-in.	25-6	27-0		52-0
Cranes	(2) 50-ton	...		...
Charging bay				
Length, ft-in.	920-0	2150-0		1232-0
Width, ft-in.	57-5	53-0		87-3
Cranes	(4) 5-ton overhead chargers	(3) 100/25-ton (2) 85/25-ton (7) 7.5-ton floor chargers		(2) 150/40/20-ton (3) 12-ton chargers
Pouring bay				
Length, ft-in.	977-0	2150-0		1232-0
Width, ft-in.	57-0	54-0		84-3
Cranes	(3) 130/40/10-ton	(1) 40/10-ton; (2) 175/40/10-ton (2) 200/40/15-ton; (3) 250/50/20-ton		(3) 400/70/25-ton
Ingot leanto				
Length, ft-in.	...	...		700-0
Width, ft-in.	...	...		37-0
Cranes	...	(1) 35-ton		...
Mold yard				
Length, ft-in.	...	(1) 410-0; (1) 440-0; (1) 318-0		700-0
Width, ft-in.	...	90-0		104-6
Cranes	...	(1) 40-ton; (1) 30-ton; (1) 30-ton		(2) 40-ton
Stripper building				
Length, ft-in.	112-0	(1) 194-0; (1) 144-0		380-0
Width, ft-in.	39-2	(1) 57-0; (1) 69-0		69-0
Cranes	(1) 125-ton	(1) 150-ton; (1) 200-ton		(1) 200-ton (1) 400-ton
Bin building				
Length, ft-in.	...	...		280-0
Width, ft-in.	...	...		102-0
Cranes	...	...		(1) 15-ton

big-end-down ingots 22½ in. x 24½ in. x 84½ in. and 22 in. x 34 in. x 78 in. and to some extent into big-end-up hot-topped ingots 27 ¾ in. x 27 ¾ in. x 77 ¾ in. Before use, molds are sprayed with a graphite emulsion at the pouring stand.

There are four pouring platforms. Another extended platform provides hot-topping facilities.

Slag, which runs about 335 lb per ton of ingots, is run into pots which are then moved to a dumping area where it is processed by an outside contractor for recovery of metallics.

Also in the pouring bay are a stopper rod drying oven and a rod straightening press.

No. 2 shop—In this shop, one 170-ton furnace and one 200-ton furnace are of all-basic construction. The remainder are all built of conventional refractories. All furnace bottoms are approximately 39 in. thick at the furnace center.

The product of this shop runs about 39 per cent open top rimmed steel, 17 per cent bottle top ingots, 39 per cent open top killed steel and 5 per cent hot topped killed steel. The grades average about 62 per cent 0.10 per cent or less carbon, 28 per cent 0.11 to 0.25 carbon, 8 per cent 0.26 to 0.65 carbon and the rest over 0.65 carbon.

Furnace charges vary according to the practice employed. In the 170-ton furnaces the charge runs 410,000 lb for flush heats, 390,000 lb for scrap heats. The 200-ton furnaces take 485,000 lb or 460,000 lb.

Hot metal is brought from the blast furnaces in No. 2 and No. 3 plants in mixer type ladles. Three hot metal stations serve this shop. A 600-ton mixer is located at one end, a 1200-ton mixer at the other end, and about mid-shop, a station at which the metal is transferred directly from the ladle car into the hot metal ladle. Hot metal use averages about 50.2 per cent of the metallic charges.

Flux consumption per ton of steel runs 140 lb of limestone, 14 lb of burnt lime and 6 lb of fluorspar.

Rimmed heats are deoxidized with manganese and aluminum added in the ladle and aluminum in the molds. For semikilled heats, manganese, silicon and aluminum are added in the ladle and aluminum in the molds. Killed steel is deoxidized by silicon, silicomanganese and manganese in the bath and manganese, silicon and aluminum in the ladle. Consumption of deoxidizers and ferroalloys runs about 20 lb per ton of ingots.

Fuel oil is the principal fuel (99 per cent) in No. 2 shop. It comes by pipe line directly from a refinery nearby and is stored in a 1,000,000-gal tank and three 200,000-gal tanks. The oil is heated by two horizontal four-pass heaters near the center of the shop. Temperature is held at 200 to 250 F by automatic viscosity control.

Oil is delivered at approximately 120-psi pressure to artillery type water-cooled burners. Input is held at 650 gal per hr during melt-down, 500 gal per hr during the lime boil and 550 gal per hr during the working period. Combustion air is supplied by forced draft fans of 15,000 and 25,000-cfm capacity. Fuel consumption averages 3,587,000 Btu per ton of ingots.

Each furnace is provided with a furnace pressure recorder and controller, and recorders on oil flow, checker temperatures, air and gas flow and boiler drafts. In addition, eleven furnaces have steam-fuel ratio and fuel-air ratio control and automatic reversal equipment. All furnaces are served by immersion thermocouple recorders and two have continuous oxygen analyzers.

Heat times average 10.02 hr charge-to-tap or 10.97 hr tap-to-tap, giving production rates of 19.7 tons per hr net, 18.0 tons per hr gross.

In this shop, oxygen is introduced during melt-down through the oil burner. For decarbonization on low carbon grades of steel, oxygen is introduced directly to the bath through 1-in. pipe inserted through the wicket holes of the doors. This application is started at about 0.45 per cent carbon and continued for approximately 50 minutes.

Heats average 175 tons from the small furnaces and 205 tons from the larger units. Steel is poured into big-end-down molds, 27⅜ in. x 27⅜ in. x 90 in., 26⅝ x 36½ in. x 80 in., 32 in. x 36⅜ x 92 in., 25⅞ in. x 43 in. x 80 in., 25⅞ in. x 43 in. x 90 in., and 30⅝ in. x 54 in. x 80 in.; bottle top molds 27½ in. x 45⅞ in. x 90 in.; and big-end-up molds 27¾ in. x 27¾ in. x 77¾ in., 27⅞ in. x 42 ½ in. x 80 in., and 29 in. x 43 in. x 76 in.

In the pouring bay are six pouring platforms.

Slag averages about 375 lb per ton of ingots. It is run into pots and moved to a dump where it is processed by an outside contractor to reclaim metallics.

No. 3 Shop—The furnaces in this newest shop are 93 ft-4 in. long and 28 ft-3 in. wide overall, outside of the buckstays. They have sprung silica roofs with zebra pattern front and back. Bottoms are about 44 in. thick at the center of the furnace. The furnaces have basic end panels and wing walls; three furnaces have suspended basic port roofs.

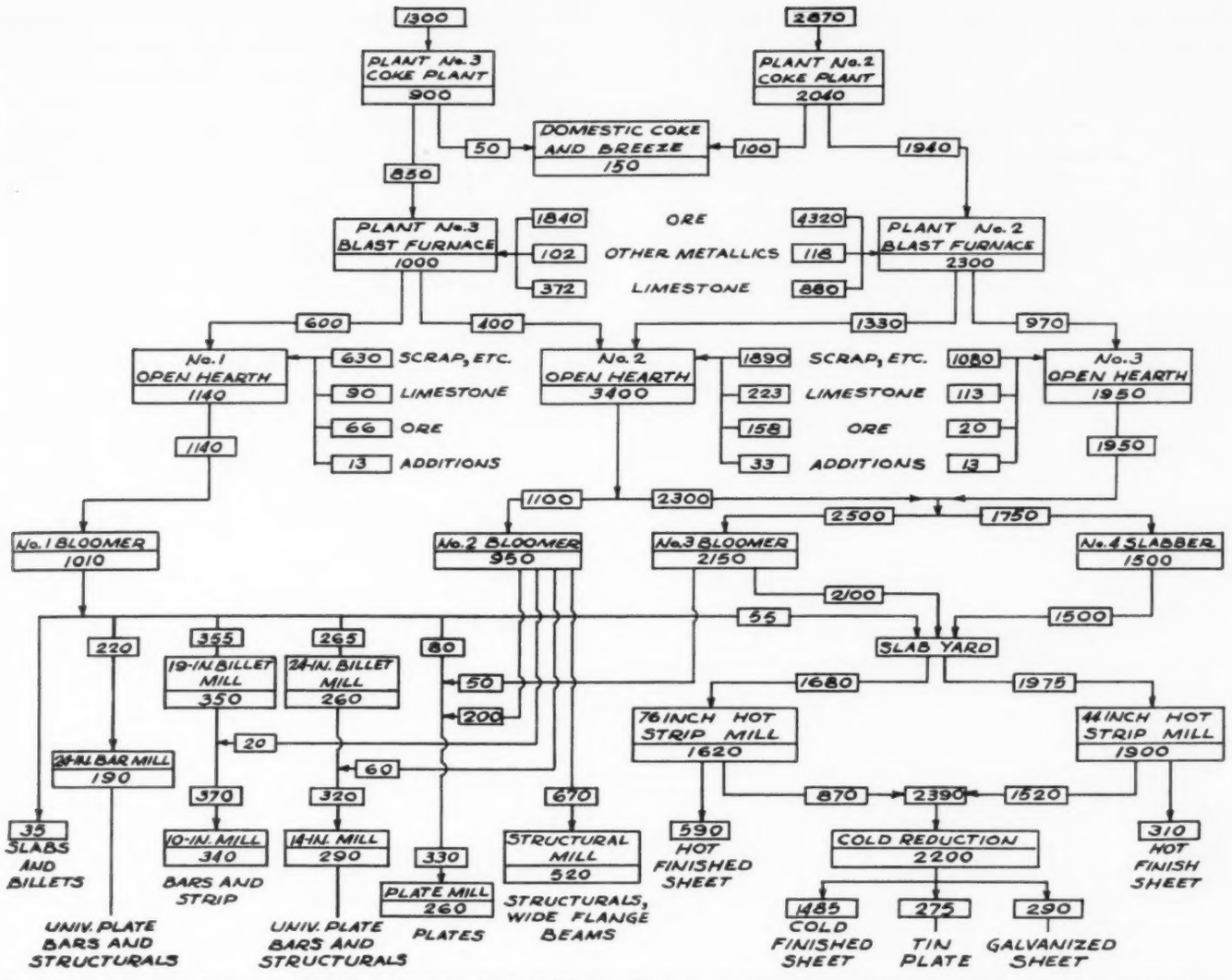
Six of these furnaces have double-pass checkers. Dimensions of these regenerators vary somewhat. Three furnaces have hot passes 14 ft-3 in. long, idle passes 2 ft-9 in. long, and cold passes 10 ft-9 in. long. The other three furnaces have hot passes 23 ft-2 in. long, idle passes 3 ft-10 in. long and cold passes 10 ft-9 in. long. All passes are 22 ft-11 in. wide inside the brickwork. Checker work is built with 11 in. x 6 in. x 3 in. brick in the hot passes, giving 9½ x 9½-in. flues. In the cold passes, flues are 7½ x 7 ½ in., formed of 9 in. x 6 in. x 3 in. brick. All checkerwork is laid up in chimney flue design. Regenerators are 26 ft-11 13/16 in. high, floor to roof. Checkerwork is built to 16 ft-1½ in. or 16 ft-6 in. height. Checkerwork volume in the smaller chambers is 5760 cu ft in the hot pass, 4340 cu ft in the cold pass, for a total of 10,100 cu ft on each end of the furnace. In the larger chambers, the hot pass has 9572 cu ft and the cold pass 4442 cu ft, for a total of 14,014 cu ft on each end.

Furnace charges, consisting of about 40 per cent hot metal and 60 per cent scrap, total 690,000 to 790,000 lb.

Hot metal comes from the blast furnaces in mixer type hot metal cars. The metal is poured from these cars at ground level into ladles carried by a car on a depressed track into the charging aisle. The ladles are then handled by overhead crane.

Flux consumption average 144.7 lb per ton of ingots. Ferroalloy additions run 13.2 lb and deoxidizers 2.2 lb per ton of ingots.

The furnaces are fired entirely with fuel oil through water-cooled artillery type burners. Oil comes from the plant storage tanks previously mentioned or from barge, tank car or truck. Two 250,000-gal tanks provide reserve storage at No. 3 shop. Oil temperature is main-



Hypothetical flow chart of material in Indiana Harbor Works. Figures, in thousands of tons per year, do not represent capacities but merely probable quantities in the present plant as now constituted. There are some additional cross-flows but only of minor proportions.

tained at about 190 F by automatic viscosity control.

Each furnace has a complete complement of instruments and controls, including automatic reversal, fuel-air ratio control and recorder, steam-fuel ratio control and recorder, furnace pressure regulator, roof temperature recorder and controller, bath temperature recorder, oxygen flow recorder, oil flow regulator and checker temperature recorder. Combustion air comes from forced draft fans of 30,000 and 50,000-cfm capacity.

Time of heats averages 9.09 hr, charge-to-tap, or 10.06 hr, tap-to-tap, giving production rates of 35.36 tons per hr charge-to-tap and 31.95 tons per hr tap-to-tap. Fuel consumption runs, 3,100,000 Btu per ton of ingots.

Oxygen is used for decarbonization of low carbon heats. It is introduced to the bath through 1-in. pipe lances. Consumption averages 20.1 cu ft per ton of ingots produced.

Heats average 321.4 tons. The steel is poured into big-end-down molds 30 in. x 48 in. x 80 in., 30⅝ x 54 in. x 90 in., 30 in. x 65 in. x 80 in., or 30 in. x 79 in. x 80 in., or into bottle top molds 27⅝ in. x 57 in. x 90 in. Molds are sprayed inside with a graphite solution before each use.

Slag runs about 75,000 lb per heat (20,000 lb flush slag, 55,000 lb tapping slag). It is taken to a dump for processing to reclaim metallics.

BLOOMING AND BILLET MILLS—NO. 1 PLANT

The mills in Plant No. 1 are among the oldest in the plant and include a 36-in. blooming mill (No. 1) with a 24-in. three-high billet mill and a 19-in. continuous billet mill, a 24-in. bar mill and a 100-in. sheared plate mill.

Some details of the No. 1 bloomer and its soaking pits are given in Table VI. Ingots (principally from No. 1 open hearth) are heated in ten soaking pits, arranged in two 3-hole blocks and two 2-hole blocks. Ingots are handled into and out of the pits by two 15-ton pit cranes.

The ingots are charged at temperatures averaging about 1300 F. Fuel consumption of the pits approximates 1,420,000 Btu per ton, some 20 per cent of which is blast furnace gas, 80 per cent coke oven gas.

The heated ingot is brought to the approach table by pit crane, placed in an ingot buggy tilting box, and then passes over the approach tables and front mill table to the mill.

The mill rolls are 12 ft-8¾ in. long overall. Their

barrel length is 74 in., with a 7½-in. pass, a 10⅞-in. pass and a 42-in. bullhead. The top roll has a bullhead diameter of 29⅞ in. and a collar diameter of 31⅝ in. The bottom roll bullhead is 30⅛ in. in diameter, the collars 31⅞ in. The necks are 20 in. in diameter.

The front left sideguard is equipped with manipulator fingers for turning the ingot between passes.

Data on ingot sizes, product sizes and rolling rates are given in Table VI.

When the 36-in. mill is rolling slabs, product is pushed from the table just beyond the shear onto skids and then removed by crane. Blooms may follow several paths. They can move straight ahead to the three-high billet mill, they can move through this idle mill to a transfer leading to an adjacent billet yard serving the 24-in. bar mill, they can follow the blooming mill line still farther to a pusher and cradle, or they can be moved over a 100-ft transfer following the blooming mill shear to a parallel mill line containing the 19-in. continuous billet mill.

24-in. billet mill—This three-high stand is located about 320 ft from and in line with the blooming mill. It is approximately 200 ft from the shear.

The alloy steel rolls have a body length of 60 in., a diameter of 25⅝ in. They run in composition bearings.

The mill is driven by 3000-hp, 2200-volt 245-rpm wound-rotor motor. Reduction gears of 36-in. face, ¾-in. diametral pitch give a reduction ratio of 2.87, giving a roll speed of 85 rpm or a mill speed of about 510 fpm. A 22-ft flywheel is mounted on the low speed shaft. Mill pinions are cast herringbone with 24-in. pitch diameters. Tilting tables on both sides of the mill handle the steel between passes.

Blooms to be rolled on this mill are 7 in. x 6 in., 75 to 76 ft long. They are reduced to 4, 4½, 5, 5½ and 6-in. squares or 5 in. x 4-in. billets. The mill rolls at an average rate of 110 tons per hour but can turn out 1200 tons or more per 8-hr turn.

Product from this mill goes to a 600-ton shear capable of cutting sections up to 6 in. x 6 in., located about 200 ft from the mill. The billets then pass over a hot bed 18 ft wide x 26 ft-8 in. long to storage. They are then moved by rail, principally to the 14-in. merchant mill.

19-in. billet mill—This continuous mill lies in a line paralleling the blooming mill line and about 23 ft to the right. A 100-ft transfer connects the two lines.

The mill, which was put into operation in 1927, consists of eight 2-high stands and four vertical edgers. The first two horizontal stands are 24-in. units; the rest are 19 in. Stand spacing and speeds are as follows:

Stand	Distance from preceding stand, ft-in.	Roll rpm
No. 1 edger (18 in.)	. . .	10.205/20.41
No. 1	7–5.9	7.205/14.41
No. 2	13–6	9.935/19.87
No. 2 edger (16 in.)	18–5.6	42.85
No. 3	5–6.4	24.265
No. 4	9–6	34.43
No. 3 edger (16 in.)	9–0	102.6
No. 5	9–0	48.41
No. 6	9–6	70.095
No. 4 edger (12 in).	9–0	325
No. 7	9–0	95.54
No. 8	9–6	121.91

All roll necks operate in composition bearings.

An up-and-down-cut shear is located just ahead of the

The 24-in. bar mill, located in No. 1 Plant, has four stands side by side, all driven by two 3000-hp motors. It produces bars, structurals and universal plate.

mill. A steam-operated flying shear is installed at the exit.

No. 1 edger and No. 1 and 2 stands are driven through a reduction set and bevel gears by a 3000-hp, 2200-volt, 500–250-rpm wound-rotor motor. Speed variation is obtained by use of a 900-hp Scherbius generator set. Stands No. 3, 4, 5, 6, 7 and 8 and No. 3 edger are driven through reduction gears, shaft and bevel gears by a 7500-hp, 2200-volt, 368-rpm wound-rotor motor. No. 2 and 4 edgers are driven individually.

Hydraulic sprays of 500-psi pressure are used for descaling on the six 19-in. stands.

This mill rolls 7 in. x 6-in. billets, 77 ft long, into 3⅛, 3, 2⅝, 2½, 2¼, 2 and 1¾-in. squares at an average rate of 110 tons per hr. The mill has rolled 1257 tons per 8-hr turn. This mill and the three-high mill have combined to roll 1415 tons in an 8-hr turn.

Product from the continuous mill continues over the runout table and is moved off by a skew table to a 107 x 30-ft cooling bed. Most of the product goes to the 10-in. merchant mill for rerolling.

24-IN. BAR MILL

Originally installed in 1908, the 24-in. bar mill is one of the older units of the plant. It is located adjacent to the No. 1 blooming mill in Plant No. 1 and gets most of its blooms from that mill. Some 10 to 20 per cent of its tonnage is charged hot from the blooming mill.

The steel is heated in two continuous furnaces with hearths 44 ft-10½ in. long x 13 ft wide. These furnaces are fired with coke oven gas and have automatic controls on fuel-air ratio and furnace pressure. Each furnace is nominally rated at 30 tons per hr. Fuel consumption runs about 3,320,000 Btu per ton.

Steel is brought to the furnace charging skids by crane and is moved through the furnaces by hydraulically-operated pushers.

The mill itself consists of four 2-high stands, side by side, with a 3000-hp, 750-volt, 70/150-rpm d-c motor at one end of the train and a 3000-hp, 750-volt, 70/175-rpm motor at the other end. Both motors are operated as reversing drives, drawing power from a motor-generator set consisting of two 3000-kw d-c generators driven at 370 rpm by a 3750-hp, 2200-volt induction motor.

No. 1 stand is a universal mill, with 24 x 44-in. horizontal rolls and four vertical rolls 15⅞ in. x 20¼ in. This stand acts as a rougher when rolling universal plate, with No. 2 stand putting on two finishing passes. In this case, No. 1 motor drives No. 1 stand and No. 2 motor drives No. 2 stand through the idling No. 3 and 4 stands. The rolls in No. 2, 3 and 4 stands are 25 x 60 in.

When rolling bars or shapes, No. 1 motor usually drives stands No. 1, 2 and 3, with No. 2 stand bypassed on the rolling schedule. No. 2 motor then drives only No. 4 stand.

This mill receives blooms ranging 4 in. to 7 in. square x 7 ft to 12 ft-4 in. long and 380 to 2060 lb in weight, and slabs 5 to 27 in. wide x 3 to 8 in. thick. It reduces them into squares from 2 to 5 in., rounds 3 to 5 in. in diameter, angles from 5 in. x 3 in. to 6 in. x 6 in., channels 6 to 13 in., I-beams 5 to 7 in., Z-bars 4 to 5 in. and many special shapes, or to universal plate ¼ to 4 in. thick and 6 to 26½ in. wide. The mill produces at an average rate of 45 tons per hr and has set records of 816 tons per 8-hr turn, 1930 tons per day and 28,000 tons per month.

As the steel is rolled, it is transferred from stand to stand over floor plates by cables and chains with "ducking dogs."

Plates finished out of No. 2 stand proceed over a runout table to a shear and then to a hot bed which will accommodate lengths up to about 70 ft. A straightener is incorporated into this hot bed. The plate then passes over a second hot bed and over another table line in the reverse direction to another shear and a piler.

Sections finished out of No. 4 stand proceed over the runout table to two hot saws, then over two hot beds to a table line running in the reverse direction to an angle shear and cradles.

Steam jets and hydraulic descaling sprays may be used at various points in the mill to improve surface quality.

SHEARED PLATE MILL

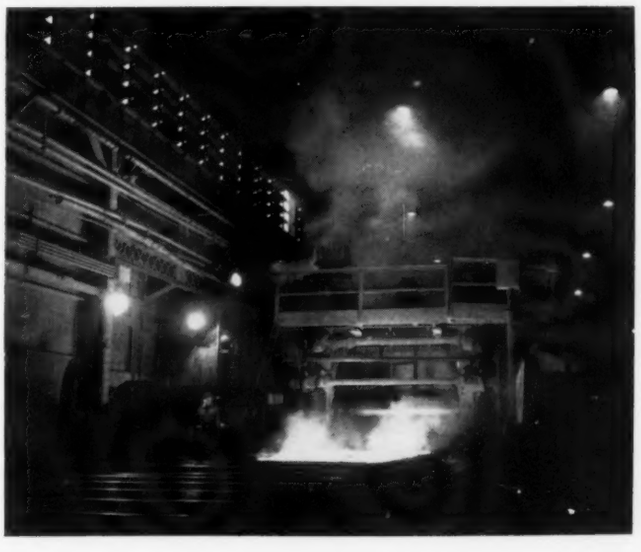
The sheared plate mill was one of the early installations in Plant No. 1, beginning operation in 1913 as a 90-in. mill. It has since been widened three times to the present 108 in. This mill receives slabs from all four blooming mills in the plant. Slabs are brought in railroad cars and are usually scarfed manually in the plate mill slab yard. Some 10 or 12 per cent of the slabs may come already machine scarfed from Nos. 2, 3 or 4 blooming mills.

Slabs range from 30 to 50 in. in width and 3 to 9¼ in. thick. They are carried by magnet crane to the furnace charging table, and moved into and through the furnace by two hydraulically-operated pushers.

The single furnace is a continuous, triple-fired, recuperative unit 20 ft wide x 56 ft long overall. It is fired with coke oven gas or fuel oil and is manually controlled. Automatic controls are to be installed soon on fuel-air ratio, temperature and furnace pressure. Heating time averages about 1½ hr. Fuel consumption runs 2,800,000 Btu per ton of slabs heated.

As a heated slab is pushed out of the furnace, it proceeds to the mill, a single stand three-high unit. Mill

The sheared plate mill, installed as a 90-in. unit in 1913, has been widened three times to bring it to its present 108 in.



No. 2 blooming mill, a 46-in. unit, was started up in 1953, replacing an old bloomer. It is driven by a 6500-hp, 650-volt motor.

No. 3 blooming mill, also a 46-in. unit, is located between the furnace ends of the two hot strip mills.

rolls have a body length of 108 in., with top and bottom rolls 35½ in. in diameter, the middle roll 22½ in. in diameter. They are of nickel grain, single poured iron, 68 to 72 scleroscope hardness. The top roll is balanced by counterweight. The middle roll is shifted hydraulically. Roll necks run in bronze bearings, lubricated with grease from a motor-driven pump.

Mill screws are 10 in. in diameter, 1¼ in. pitch, and are operated by a single 60-hp motor. Maximum roll lift is 11 in. Housing posts are 433 sq in. in cross-sectional area.

On each side of the mill stand is a tilting table 32 ft-6 ¾ in. long, driven by two 150-hp motors in series.

The plate mill is driven by a 2000-hp, 2200-volt, 245-rpm wound-rotor motor operating through a rope drive of 4.537 reduction ratio, giving a roll speed of 54 rpm or 481 fpm face speed.

The lead spindle is 17¼ in. in diameter x 6 ft-7¾ in. long. Mill spindles are 16 in. in diameter and 10 ft-2 in. long. Pinions are 42 in. wide and have cut herringbone teeth. Top and bottom pinions are 35.2–in. pitch diameter and have 22 teeth. The middle pinion is 22.4 in. diametral pitch and has 14 teeth.

The slab is descaled during rolling by hydraulic sprays of 1000-psi pressure located top and bottom on the entry side, and on top on the exit side.

Plate leaving the mill passes through a roller leveler, a marking conveyer, an end shear, a rotary side shear, two-high pinch rolls and on to a turnover table and a piler table and skids. A caster bed and resquaring shear is located adjacent to the piler table. The shears cut material up to 1½ in. thick. Heavier plate is removed from the mill table and torch-cut.

Product from this mill runs from 3/16 to 3 in. in thickness, and up to 84 in. wide for 3/16-in. plate, 96 in. wide for heavier material. The mill averages about 41 tons per hr but has set records of 89.2 tons per hr, 653 tons per hr per 8-hr turn and 29,377 tons in a month.

BLOOMING MILLS—NO. 2 PLANT

Three additional blooming mills are installed in No. 2 plant. Some details of these units are included in Table VI.

No. 2 bloomer is located adjacent to No. 2 open hearth shop. It is a 46-in. two-high reversing mill put into operation in 1953, replacing an old 40-in. unit.

This mill is served by 22 soaking pits which vary in size and design. There are three 2-hole rows of bottom-fired recuperative pits, two 2-hole rows of regenerative pits and three 4-hole rows of regenerative pits. Their dimensions and characteristics are shown in Table VI.

Ingots, principally from No. 2 open hearth shop, are charged into and drawn from the pits by three pit cranes, two rated at 15 tons, one at 25 tons. An ingot buggy carries the heated ingot to the mill.

Rolls used in this mill are 17-ft 1 in. long overall, with a body 100 in. long x 41½ in. in diameter. The body carries a 12¾-in. groove and an 8½ in. groove for edging and a 69 9/16 in. bull head. Roll necks are 27 in. in diameter.

The front and back sideguards on the mill side have

manipulator fingers to edge the steel between passes.

Power for the mill auxiliaries operating under adjustable voltage control comes from two motor-generator sets which, combined, provide two 150-kw generators for screwdown drives, two 150-kw generators for front and back tables, two 150-kw generators for sideguards, a 50-kw generator for feed rolls, a 150-kw generator for the auxiliary tables and a 125-kw generator for the scarfing tables. Each set is driven by an 800-hp motor.

An automatic scarfing machine, placed 110 ft from the mill, can scarf top and bottom and both edges of the slab and blooms as desired. It will remove $\frac{1}{32}$ to $\frac{1}{8}$ in. of surface metal, and operates at 65 to 195 fpm.

The blooming mill shear, located 90 ft beyond the scarfer, will cut 600 sq in. of hot steel. It is driven by two 500-hp d-c motors. The screw-operated shear gage will measure lengths from 3 to 25 ft. Crops fall through a chute into a skip car which can be hoisted up an inclined track and dumped into a scrap car. A scale to weigh blooms and slabs is installed in the table following the shear.

The shear motors draw power from two 500-kw d-c generators driven by a 1500-hp motor.

Approximately 110 ft beyond the shear is a chain-type transfer over which slabs are moved to short length of parallel table leading to a tilting piler table and a piler car in an adjacent building aisle.

About 225 ft beyond the slab transfer is another chain type transfer which carries blooms from the mill into the adjacent storage aisle.

No. 2 bloomer is lubricated by three circulating oil systems and three grease systems.

Data on rolling rates, and ingot and product sizes are shown in Table VI. Product from this mill has been about 67 per cent slabs, 23 per cent blooms and 10 per cent shape blanks, but this mix will change since the start-up of the new slabbing mill.

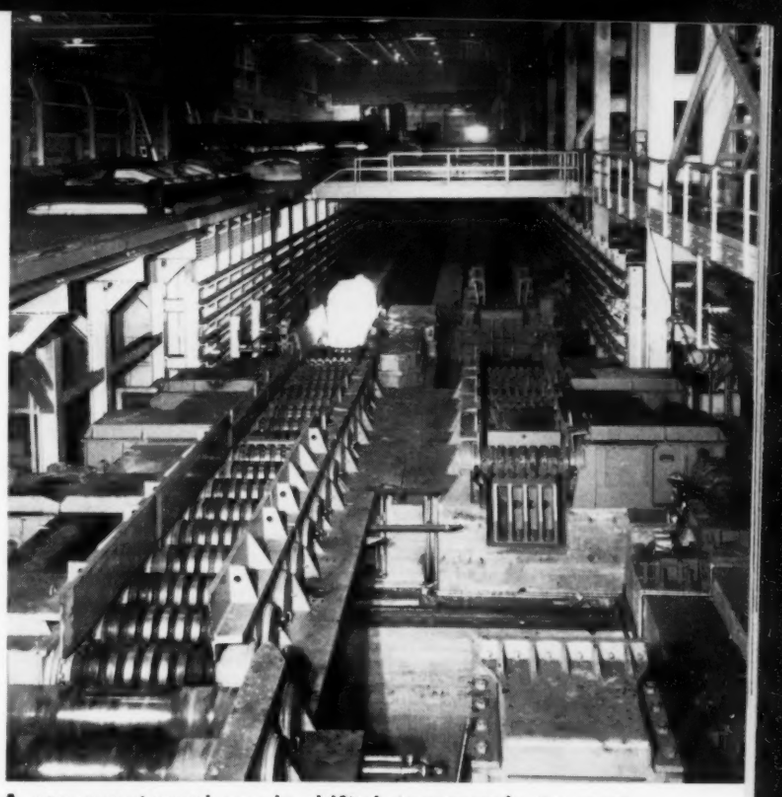
No. 3 blooming mill was put into operation in 1936, primarily to roll slabs for the 76-in. strip mill. It is located between the furnace ends of the 76 and 44-in. hot strip mills, and almost in line with them. Details of this mill are listed in Table VI.

This mill is served by 26 soaking pits, of which 14 are of circular design, 16 ft in diameter x 9 ft-4 in. deep. There are also 12 top-fired one-way pits 21 ft long x 8 ft-6 in. wide x 13 ft-6 in. deep. The circular pits and six of the rectangular pits form a line paralleling the mill line. Six rectangular pits are on the other side of the ingot buggy track, near the mill.

Each circular pit is fired tangentially with 14 combination oil and coke oven gas burners around the circumference. Rectangular pits are fired through combination burners near the top. Six rectangular pits have metallic tubular recuperators. All the other pits operate on cold air, with the waste gases flowing through flues to waste heat boilers. Air for combustion is supplied by 5400-cfm fans.

Ingots from Nos. 2 and 3 open hearths are charged to and drawn from the pits by three 25/5-ton pit cranes. A remotely controlled tilting buggy carries the ingot to the mill approach table which is 40 ft-8 in. long. An ingot scale and turner is incorporated in the table.

No. 3 bloomer is a two-high 46 x 100-in. high-lift, reversing slabbing mill. The rolls are $43\frac{5}{8}$ in. in diameter and run in babbitted bearings with bronze inserts, lubricated by an automatic grease system. The rolls carry grooves of 12 $21\frac{1}{32}$ in., 8 in. and 5 in., and a 60-in. bullhead.



A conveyor-topped car is shifted transversely to move ingots from either ingot buggy into line with the approach table of No. 4 blooming mill.

Manipulator fingers are provided on the sideguards in front and back of the mill.

Power for the mill auxiliaries under adjustable voltage control is furnished by two motor-generator sets, each composed of four 250-volt d-c generators (three of 135 kw, one of 250 kw) driven by a 1000-hp, 6600-volt synchronous motor.

An automatic scarfing machine, which can condition

No. 4 mill is a 46-in. x 90-in. universal slabbing mill put into operation in 1958. It is driven by two 6000-hp motors with a 4000-hp motor on the vertical rolls.

TABLE VI

Blooming Mills

Mill No.	1	2	3	4
Year completed	1905—Rebuilt 1935	1953	1936	1958
Size, in.	36	46	46	46 x 90
Type	2-high reversing	2-high reversing	2-high reversing	Reversing—universal
Housing, post area, sq in.	375	600	520	750
Roll diameter, in.	32	44 max	43⅝	45
Roll body length, in.	74	100	100	90
Kind of rolls	Alloy steel	Alloy steel	Alloy steel	Alloy steel
Type of roll balance	Hydraulic	Hydraulic	Mechanical counterweight	Mechanical counterweight
Maximum roll lift, in.	36	61⅛	53	84
Roll lift speed, in. per min	250	480	325	600
Screw diameter, in.	9½	16	16	18
Screw pitch, in.	1¾	2	2	2¼
Screw motor, no. and hp	(2) 80	(2) 150	(2) 150	(2) 200
Screwdown control	Magnetic	Adjustable voltage	Adjustable voltage	Adjustable voltage
Kind of roll neck bearings	Babbitt & composition	Babbitt	Bronze & Babbitt	Roller
Length of mill spindles, ft-in.	19-2¾	24-0	24-0	36-0
Diameter of mill spindles, in.	18	12	21	23
Type of pinion	Double cut helical	Double cut helical	Double cut helical	None
Pinion face width, in.	48½	65	65	...
Pinion pitch diameter, in.	36	46	46	...
No. of pinion teeth	13	20	20	...
Main drive, hp	7000	6500	7000	(2) 6000
Main drive, voltage	700	650	700	750
Main drive, rpm	0/120	0/120	0/50/120	0/40/80
Operating torque, lb-ft	1,250,000	1,250,000	1,650,000	1,600,000
Max. torque, lb-ft	2,000,000	1,980,000	2,020,000	3,500,000
Motor-generator set generators, no. and kw	(2) 2500	(2) 2500	(2) 3000	(6) 2500
Motor-generator set drive, hp	3750	6250	5000	10,000
Motor-generator set, rpm	368	368	370	514
Motor-generator set, voltage	2200	2200	6600	13,200
Flywheel weight, lb	118,000	110,000	140,000	140,000
Flywheel diameter, ft-in.	14-9	18-0	15-0	13-9
Flywheel construction	Cast	Cast	Steel plate	Steel plate
Sideguard drive no. and hp	(4) 150	(4) 150	(4) 150	(4) 200
Finger drive, no. and hp	(2) 80	(2) 100	(4) 75	(2) 150
Sideguard control	Magnetic	Adjustable voltage	Adjustable voltage	Adjustable voltage
Length, front mill table, ft-in.	45-0	46-8	34-11	31-5
Front table drive, no. and hp	(2) 150	(2) 150; (2) 80	(2) 150	(14) 62
Front table control	Magnetic	Adjustable voltage	Adjustable voltage	Adjustable voltage
Length, back mill table, ft-in.	45-0	46-8	34-11	31-5
Back table drive, no. and hp	(2) 150	(2) 150; (2) 80	(2) 150	(14) 62
Back table control	Magnetic	Adjustable voltage	Adjustable voltage	Adjustable voltage
Vertical roll location	...	...	...	8 ft-1 in. beyond horizontal rolls
Vertical roll diameter, in.	...	...	...	36
Vertical roll body length, in.	...	...	...	84
Kind of bearings	...	...	...	Roller
Vertical roll drive, hp	...	...	...	4000
Vertical roll drive, rpm	...	...	...	0/60/150
Vertical roll drive, voltage	...	...	...	750
Maximum opening between rolls, in.	...	...	...	90
Adjusting motor, no. and hp	...	...	...	(1) 150/300
Any descaling on mill?	None	None	None	None
Mill scale disposal	Manually	Sluiced to sump	Sluiced to sump	Sluiced to sump
Shear, type	Downcut with depressing table	Downcut with depressing table	1200-ton down-cut	1875-ton down-up cut
Shear location	122 ft from mill	200 ft from mill	133 ft-5½ in. from mill	211 ft-6½ in. from mill
Maximum size cut, in.	9½ x 9½; 32 × 6½	600 sq in.	900 sq in.	900 sq in.
No. and hp of drive	(1) 150	(2) 500	(2) 275	(2) 500/1100
Shear control	Magnetic	Adjustable voltage	Adjustable voltage	Adjustable voltage
Crop disposal	Dropped into box	Chuted to hoist	Chuted to conveyor	Chuted into car
Ingot sizes, in.	22½ x 24½, 9600 lb to 26 x 36, 17,000 lb	27¾ x 27¾, 12,000 lb to 30 x 62½, 34,000 lb	26 x 36, 17,000 lb to 30 x 54, 28,400 lb	26 x 36, 17,000 lb to 30 x 79, 41,000 lb
Product sizes, in.	Blooms 5 x 5 to 9½ x 9½	Blooms 7 x 6 to 12¾ x 12¾	Slabs 18 x 3 to 51 x 6½	Slabs 18 x 3 to 76 x 10
	Slabs 6¼ x 4 to 32 x 6½	Slabs 19 x 3½ to 59 x 12¾	Blooms 6 x 6 to 10 x 9	
Average hourly rolling	130	159	292	390
Maximum hourly rolling	210	376	442	481
Maximum turn rolling	1649	2478	3116	2497
Maximum day rolling	3792	5660	7908	4669 (2 turns)
Maximum month rolling	94,584	136,107	205,165	130,000
Rolling speed, maximum fpm	920	1392	1370	940
Scarfer	None	110 ft from mill	86 ft from mill	137 ft-2 in. from mill

TABLE VI
(Continued)
Blooming Mills

Mill No.	1	2	3	4
Soaking Pits				
Number	10	22	26	18
Type	Reversing regenerative	(6) Recuperative, (16) regenerative	(14) circular; (12) one-way	One way, top fired
Length, ft-in.	(8) 11-2; (2) 12-0	(6) 20-0; (4) 18-0; (12) 13-0	(12) 21-0, (14) 16-0 diam	22-0
Width, ft-in.	(6) 11-6; (2) 10-2½; (2) 10-8¾	(6) 18-0; (4) 13-0; (12) 7-0	(12) 8-6	8-6
Depth, ft-in.	9-6	(6) 12-0; (4) 9-0; (12) 8-0	(12) 13-6	13-6
Total hearth area, sq ft	1206	4188	...	3366
Kind of fuel	Mixed coke oven and blast furnace gas	Mixed coke oven and blast furnace gas	Coke oven gas and oil	Coke oven gas and oil
Controls	Fuel-air ratio, furnace pressure, temperature	Fuel-air ratio, furnace pressure, temperature	(26) Furnace pressure; (26) Temperature; (12) Fuel-air ratio	Fuel-air ratio, temperature furnace pressure
Temp. of charged ingots, F	1200	1400	1400	1600
Average heating time	2 to 4 hr	3 to 8 hr	4 to 6 hr	4½ to 6
Average Btu per ton	1,420,000	1,400,000	1,250,000	1,250,000
Pit cranes, no. and size	(2) 15/10-ton	(2) 15/10-ton, (1) 25/30-ton	(3) 25/5-ton	(2) 35-ton

the four surfaces of slabs as desired, is installed 86 ft from the mill.

The 1200-ton down-cut slab shear, placed 43 ft-4 in. beyond the scarfer, can cut slabs 51 in. wide in thicknesses up to 9¼ in. maximum. It is driven by two 275-hp motors under adjustable voltage control, receiving power from the two auxiliary motor-generator sets previously mentioned. The shear gage can handle lengths from 3 ft-4 in. to 21 ft. Crop ends fall through a chute to a flight conveyor which carries them up and dumps them into a pit. A magnet crane moves the crops from pit to scrap car.

About 60 ft beyond the shear is a transfer which takes slabs pushed from the table and carries them about 98 ft to a parallel piler table 72 ft long. Three pushers move the slabs from the piler table to three pilers. Piles formed here are moved by drag-off bars onto skids and then removed by crane.

Product from No. 3 bloomer is almost entirely slabs for the hot strip mills. Product and ingot sizes and rolling rates are given in Table VI. The mill rolls 29 to 35 ingots per hour, depending on their size.

A considerable portion of the product goes directly to the heating furnaces serving the 76-in. hot strip mill.

No. 4 slabbing mill went into operation in 1958. It is located adjacent to the 44-in. hot strip mill and its product goes into a slab area adjacent to the hot strip slab yards. It is a 46 x 90-in. two-high universal slabbing mill.

At present, there are 18 one-way top-fired soaking pits, arranged in six rows of three pits each. There are no recuperators on these pits, but exhaust gases flow from them to six waste heat boilers. A 6500-cfm fan furnishes air for combustion to each pit. Additional pits will be necessary before this mill can attain its full capacity.

Two 35-ton pit cranes charge and draw ingots at these pits. Two 25-ton cover cranes handle the pit covers.

Ingots are carried to the mill by two traveling table-type ingot buggies running on parallel tracks.

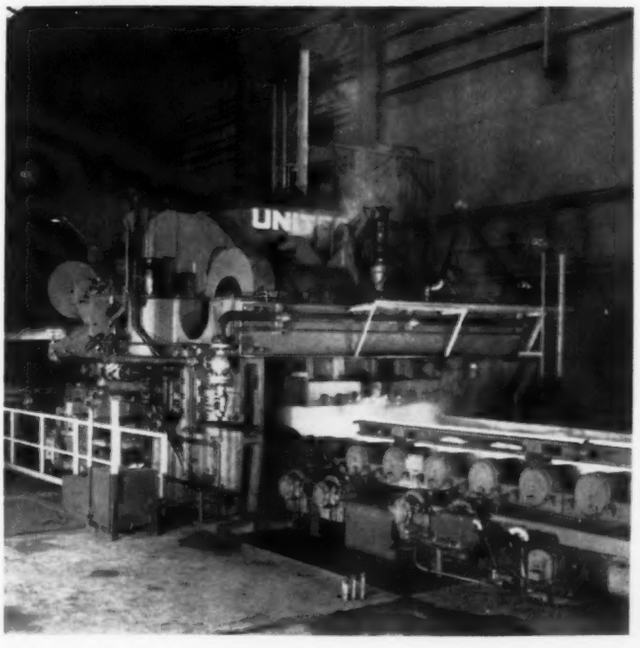
The cars are moved by a cable connected to each end of the car, operated from drums, driven by a 275/550-hp motor, at each end of each track. The cars travel at speeds up to 1200 fpm and are semiautomatically controlled by an operator in a pulpit near the mill.

At the mill there are two receiving tables, each 17 ft-6 in. long, side by side, followed by a side-shifting car. This car carries two roller tables, each 17 ft-6 in. long and driven by 35-hp motors. The car is traversed sideways by a 50-hp motor to line up with either receiving table.

The ingot then moves over the mill approach table, scale table and mill run-in table. Each of these is 31 ft 5 in. long, made up of 14 solid forged steel rollers 18 in. in diameter x 85 in. body length on 29-in. centers. The first two tables are driven by 100-hp motors at 317 fpm. The run-in table is driven by a 150/300-hp motor at 498/996 fpm.

A motor-operated ingot lift and an indicating record-

This down-and-up-cut shear, serving No. 4 slabbing mill, exerts a maximum knife pressure of 3,750,000 lb and can cut slab sections up to 900 sq in.



ing scale is incorporated into the scale table.

The mill itself is a two-high slabbing stand followed on 8 ft-1 in. centers by an attached vertical edger. Housings are of cast steel, of closed top design and tied together top and bottom by cast steel box section separators. Housing windows are 53 in. wide between steel liners x 19 ft-6 in. high. The vertical roll housings slide on liners on top and bottom separators, actuated by screws operated by a 150/300-hp motor.

There are two forged steel feed rollers 21 in. diameter x 90 in. ahead of the horizontal rolls and one between horizontal and vertical rolls. Each roller is driven by a 25.8-hp motor under adjustable voltage control.

The horizontal rolls are 46 in. in diameter with a body length of 90 in. Roll necks are 29½ in. in diameter. Vertical rolls are 37 in. in diameter x 84 in. body length, with 22-in. neck diameters. Roller bearings are applied to all roll necks.

Front and back mill tables, 31 ft-5 in. long, consist of 14 rollers each, 20 in. in diameter x 101 in. body length, on 29-in. centers, Each roller is individually driven by a 25.8-hp, 0/191-rpm motor under adjustable voltage control to give table speeds up to 1000 fpm.

Movable side guard manipulators are provided on entry and delivery sides of the mill. Sideguards are of welded steel construction about 25 ft-9 in. long and are operated through racks and pinions. Four tilting fingers are placed on each side guard on the drive side of the mill.

Leaving the mill, slabs pass over three sections of table to an automatic scarfing machine placed 137 ft-2 in. from the horizontal mill rolls.

Next in line is a down-up cut shear with maximum knife pressure of 3,750,000 lb, capable of cutting hot carbon steel slabs of sections up to 900 sq in. The knives are 85-in. long, have a 19-in. stroke and are hydraulically balanced. The shear is driven by two 500/1100-hp, 340/740-rpm and can make 18 cuts per minute. A motor operated shear gage will measure lengths from 4 to 30 ft.

Crops fall through chutes to a crop car which can be hoisted up an inclined track and dumped into a pit.

The shear is located 74 ft-4 ½ in. beyond the scarfer.

From the shear, tables carry the slabs to three push-offs and pilers about 200 ft away. In these tables is an auxiliary pusher which, in emergencies, can push crop ends off into auxiliary crop boxes. There is also a slab lift and scale, and two slab stampers.

The pilers are of elevator type and will accommodate a 39-in. high pile of slabs of 75 in. maximum width x 30 ft long. Adjacent to each piler is a slab storage rack which receives a pile of slabs from the piler. From here, slabs are moved by crane to storage.

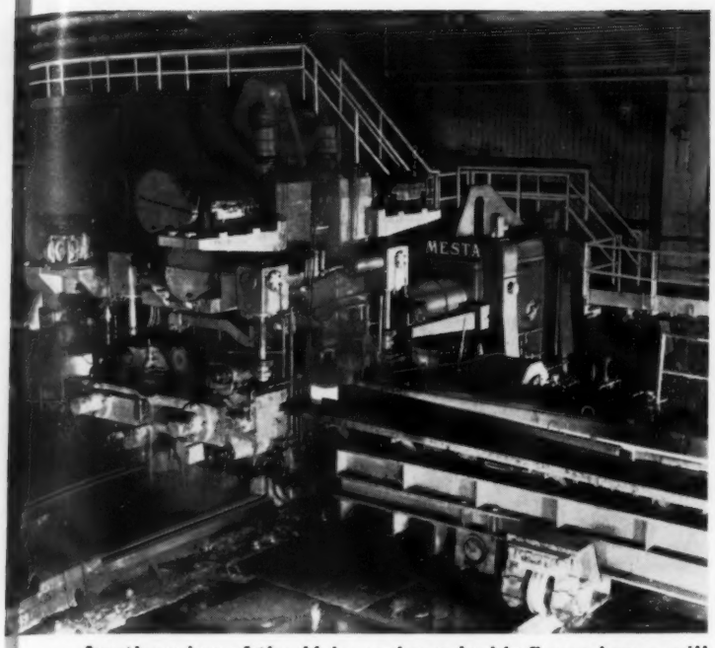
The pilers actually lie in a slab yard adjacent to the slab yard in which the charging ends of the hot strip mill furnaces are located. The two yards are connected by slab transfers.

Seven motor-operated, time controlled, centralized pressure grease systems, four manually operated centralized grease systems and two centralized circulating oil systems provide complete lubrication for No. 4 mill and its auxiliaries.

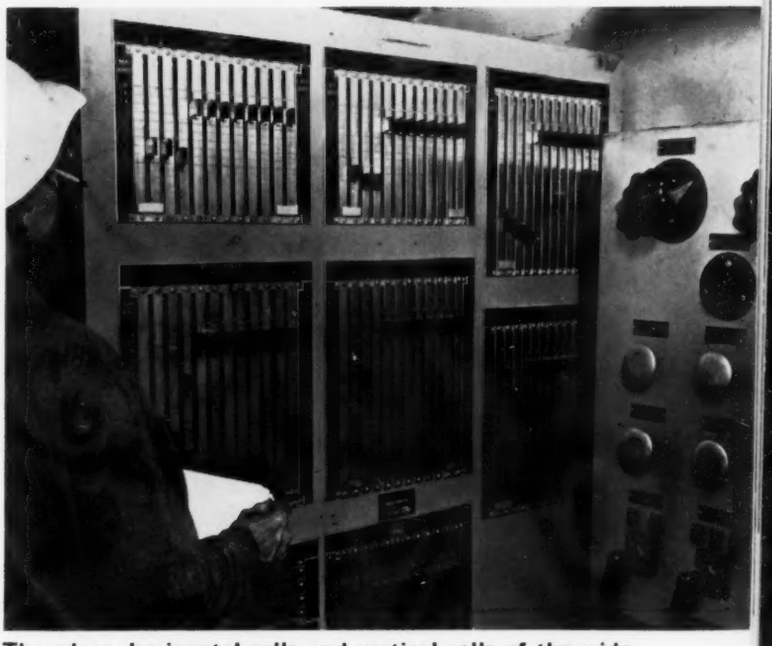
No. 4 slabbing mill and its adjustable-voltage controlled auxiliaries all operate with static switching under programmed control using punched cards. The mill can operate entirely automatically. Only one man is in the pulpit.

The main drives draw power from a 15,000-kw

View of structural mill which has been modified for wide flange beams. Entry side of 44-in. wide flange beam stand is at the right.



Another view of the 44-in. universal wide flange beam mill with traveling table. This stand is driven by a 7000-hp, 700-volt d-c motor.



The edger, horizontal rolls and vertical rolls of the wide flange beam mill are automatically controlled by this preset draft schedule board.

motor-generator set. Five auxiliary 250/500 volt motor-generator sets provide power for the auxiliaries:

Set no.	No. of generators	Total kw capacity	Auxiliaries served
1	6	950	Ingot buggy, front mill table, front fingers.
2	7	950	Ingot buggy, front mill table, back fingers, feed rollers.
3	8	1138	Screwdown, manipulator, back mill table, edger adjustment, runout table, scarfer.
4	7	900	Screwdown, manipulator, back mill table, shear entry table, scarfer tables.
5	2	1000	Shear drive motors.

No. 4 mill's product is entirely slabs for the hot strip mill.

STRUCTURAL MILL

The structural mill was originally built in 1916 as a 28-in. unit but has been modified over the years. In 1955 a 44 and a 40-in. universal stand were incorporated to broaden the product range to include wide flange beams.

Blooms and beam blanks to be reduced on this mill come from principally No. 2 blooming mill, which is located in an adjoining building and from which the blooms and blanks can be transferred directly to the structural mill furnaces. About 60 per cent of the steel charged is hot.

Heating facilities for the structural mill are being changed. The three old furnaces, 18 ft wide x 55 ft long and rated at 50 tons per hr each, are being replaced by two continuous, recuperative furnaces with hearths 72 ft-2 in. long x 24 ft wide. The new furnaces will be fired with oil or coke oven gas through combination burners. The furnaces will be equipped with automatic controls and will consume about 1,500,000 Btu per ton of steel heated. Each furnace will heat 109 tons of cold steel per hr or 153 tons per hr of steel charged hot from the bloomer.

The mill is a Belgian layout, with a 32-in. two-high reversing rougher, followed by three 28-in. stands side by side. When rolling standard structural shapes, the bloom might receive five passes in the 32-in. rougher, two, three or four passes in the three-high 28-in. rougher, two, three or four passes in the three-high 28-in. intermediate stand and a final pass in the two-high 28-in. finisher.

As modified for wide flange beams, rolls are changed in the 32-in. stand, the 28-in. rougher is replaced by another 28-in. stand made up with rolls for the new section, the 28-in. intermediate stand is removed, and the 28-in. finishing stand is replaced by a 44-in. universal stand which fits on the 28-in. stand shoes, followed closely by a 34-in. edging stand. In addition, a small section of table rolls is removed and a 40-in. universal finishing stand is set in. The beam blank may receive five passes in the 32-in. rougher, one or three passes in the 28-in. rougher, three, five or seven passes in the 44-in. stand and the edger stand, and a final pass in the 40-in. stand.

The 32-in. mill is, in essence, a small blooming mill with rolls 36 in. in diameter and 78 in. body length. It is driven by a 3250-hp, 700-volt 0/60/120 rpm d-c motor operated under the conventional adjustable voltage reversing control. Mill pinions, of 34-in. pitch diameter and 48-in. face, have 17 double helical cut teeth. The mill screws are 9 in. in diameter with 1½-in. pitch. The top roll is hydraulically balanced. Side guards are driven by four 100-hp motors; manipulator fingers are driven by two 75-hp motors.

The 28-in. train is located about 200 ft beyond the reversing stand. It has rolls of 68-in. body length and 28 in. diameter. It is driven by a 3250-hp, 700-volt,

0/60/120 rpm d-c motor. This motor, as well as the reversing rougher motor, draw power from a motor-generator set composed of two 2500-kw generators driven by a 5000-hp, 2200-volt motor.

When in use, the 28-in. intermediate and finishing stands can be coupled to the 28-in. roughing stand, or more usual now, to the motor which drives the 44-in. universal stand.

The 44-in. universal mill is a two-high 44 x 28-in. reversing mill with 34 x 15-in. vertical idler rolls in the same vertical plane as the beam section at the point of roll contact. All rolls can be adjusted independently through their screwdown systems. Rolls are hydraulically balanced.

The 34 x 33-in. edger, located 11 ft from the 44-in. stand, edges only the flange tips to control flange width. It is operated in tandem with the 44-in. stand, with the draft for all three sets of rolls regulated by a preset pass schedule board with push-button pass advance control.

The 44-in. stand is driven by a 7000-hp, 700-volt, 0/80/160-rpm d-c motor. The edger is driven by a 1400-hp, 700-volt, 90/130-rpm d-c motor. These drives receive power from a motor-generator set made up of two 3000-kw, and one 1250-kw, 700-volt d-c generators, all driven by a 6000-hp, 6600-volt, 375-rpm motor.

A maximum delivery speed of about 1800 fpm is possible from these stands.

About 200 ft beyond is the two-high universal finisher, a 40 x 28-in. unit which takes a final sizing reduction of about five per cent in the beam and flattens the flared edges delivered from the edging stand. The horizontal rolls are driven by a 3000-hp, 2200-volt, 375-rpm motor through a 5.93:1 gear reduction, giving a delivery speed of about 600 fpm. The vertical rolls are idlers. The 28-in. mill and the 44-in. universal stand are served by traveling tilting tables which tilt up and down between the upper and lower passes, and travel sideways from stand to stand.

In the runout from the mill are two structural hot-saws (a third is being added) and a stamping machine. These are followed by two hot beds, one 90 ft wide and one 135 ft wide. An additional 80 ft wide hot bed is to be put in. An eight-roll, open-end roller straightener and a seven-roll straightener are incorporated into the hot bed layout, as well as gag presses to straighten beams from 8 to 24 in. in depth and 5¼ to 12 in. flange width. The hot beds are connected by the elaborate layout of tables and transfers common to structural mills. An additional finishing aisle is being provided. Three cold saws and three gags will be available.

Steam sprays on the 32-in. mill and on the 28-in. rougher blow scale from the steel as it is being rolled. Hydraulic water sprays are provided on the 28-in. intermediate stand and on the 44-in. universal stand. On the 44-in. stand air is then used to blow the water away quickly so as not to chill the web of the beams unnecessarily.

The mill receives blooms ranging from 7 x 6 in. up to 14 x 11 in. and beam blanks up to 29 x 18 in. in lengths of 8 to 16 ft-10 in. It produces angles from 6 x 3½ in. to 8 x 8 in.; channels from 10 to 15 in.; I-beams from 7 to 24 in.; Z-bars 12⅞ in.; squares from 2 to 6 in.; rounds from 3½ to 5 in.; sheet piling and various special sections.

Shown here is the heating furnace and the roughing stands of the 10-in. merchant mill. In the foreground are spare stands made up for rapid section changes.

Rolling rates average 72 tons per hr, but the mill has set records of 170 tons per hr, 1228 tons per 8-hr turn, 3375 tons per day and 54,541 tons per month.

MERCHANT MILLS

Two merchant mills are installed in Plant No. 2. They lie side by side, adjacent to the structural mill. One is a 10-in. unit, the other 14 in. Together they provide a wide range of bars and small structural shapes.

The 10-in. bar mill is a 15-stand continuous which was put into operation in 1930. It consists of seven 14-in. roughers, three 12-in. intermediate stands, three vertical stands, and two 10-in. finishers, all in line. Table VII gives some details of the mill layout.

Billets come to the mill chiefly from the 19-in. billet mill in Plant No. 1 by rail. They range from 1¾ to 3-in. square or slabs up to 4⅝ in. wide, 27 to 30 ft in length. Weight runs from 320 to 930 lb in weight.

The billets are heated in a single continuous side-charge, side-discharge furnace with a 45 x 33-ft hearth. It is fired with coke oven gas or oil under manual control. The furnace is rated at 45 tons per hr and uses about 1,500,000 Btu per ton of steel heated. Billets are charged by a buggy charger with a motor-driven ram, and are moved through the furnace by pusher arms. A peel actuated by pinch rolls push the billets out of the furnace on to the mill table.

Some principal details of the mill are set forth in Table VII. No. 10, 12 and 14 stands are vertical edgers. The rest are two-high. No. 2 and 3 stands share a common drive motor, as do No. 4 and 5 stands. The other stands are individually driven.

TABLE VII
Merchant Mill Data

Stand	Roll		Distance from preceding stand, ft-in.	Motor			Gear ratio	Roll, rpm	Roll face speed, fpm
	Diameter, in.	Body length, in.		Hp	Voltage	Rpm			
10-in. mill									
No. 1—14 in. rougher	15	28	...	200	600	400/1200	26.6	15/45	58.7/176.1
No. 2—14 in. rougher	15	28	10-0	350	600	400/1200	20.2	19.8/59.4	71.6/214.8
No. 3—14 in. rougher	15	28	7-4				14.97	26.7/80.1	104.5/313.5
No. 4—14 in. rougher	15	28	9-0	350	600	400/1200	11.91	33.5/100.5	131/393
No. 5—14 in. rougher	15	28	7-4				9.40	42.5/127.5	166/498
No. 6—14 in. rougher	15	28	14-0	750	600	400/1200	7.04	56.7/170.1	221/663
No. 7—14-in. rougher	15	28	14-0	750	600	400/1200	5.57	72/216	282/846
No. 8—12-in. intermediate	13	24	25-0	750	600	400/1200	3.87	103/309	350/1050
No. 9—12-in. intermediate	13	24	14-0	750	600	400/1200	3.15	127/381	432/1296
No. 10—Vertical	13	18	14-0	350	600	400/900	2.20	182/409	620/1390
No. 11—12-in. intermediate	13	24	14-0	750	600	400/900	1.80	222/500	757/1700
No. 12—Vertical	13	18	14-0	350	600	400/900	1.42	281/633	955/2150
No. 13—10-in. finisher	11	18	14-0	750	600	400/900	Direct	400/900	1150/2590
No. 14—Vertical	13	18	14-0	350	600	400/900	1.16	345/775	1170/2640
No. 15—10-in. finisher	11	18	14-0	750	600	400/900	Direct	400/900	1150/2590
14-in. mill									
No. 1—20-in. rougher	19	40	...				5.36	12.55/20.5	62.5/101
No. 2—18-in. rougher	19	40	36-8				3.91	17.2/28.1	85.5/139
No. 3—18-in. rougher	19	40	48-0				2.71	24.8/40.5	123/202
No. 4—18 in. rougher	19	40	8-6				1.97	34.2/55.7	170/278
No. 5—18-in. rougher	19	40	85-0				1.38	48.7/79.5	242/396
No. 6—18-in. rougher	19	40	8-6	4700	2200	300/490	1.03	65/106.8	324/533
No. 7—14-in. finisher	15	28	...				0.60	112.3/183.5	382/720
No. 8—14-in. finisher	15	28	...				0.48	124/202.5	422/795
No. 9—14-in. finisher	15	28	...				0.60	112.3/183.5	382/720
No. 10—14-in. finisher	15	28	...				0.48	124/202.5	422/795

All of the drive motors were originally designed for a 400/800-rpm speed range. They have been changed to the speeds shown in Table VII. Further revamping of the 10-in. mill is under consideration, with a view to increasing drive power.

The drive motors draw d-c power from two 1500-kw, 600-volt generators driven by a 4200-hp motor.

Mill pinions are of double helical design, with 20-in. faces. Their pitch diameters are 14, 12 and 10 in. for the three sizes of stands, and they have 28, 24 and 20 teeth, respectively.

Roll necks run in composition bearings. Top and bottom rolls are independently adjustable through manually operated screws.

A crop shear is located ahead of the mill train and a flying shear is placed between stands No. 7 and 8.

Looping tables are installed between the last six stands of the mill.

Leaving the mill at speeds up to 2500 fpm, steel may proceed to a 462 ft x 34 ft-4 in. double inclined hot bed. A vertical down-cut shear is provided in each cold runout from the hot bed, followed by receiving cradles. Small rounds (up to about $1\frac{1}{8}$ in.) may be guided from the last finishing stand to two vertical pin reels which form coils of 30-in. inside diameter and up to $43\frac{3}{4}$-in. outside diameter. These coils are placed on a coil cooling carrier which transports them about 800 ft to a storage area beyond the hot bed. Five straightening machines for flats, rounds and angles are installed in the runout end of the mill building.

High pressure hydraulic sprays are installed at the delivery sides of Nos. 1, 2, 6, 10, 12 and 14 stands for scale removal.

The 10-in. mill rolls at an average rate of 40 tons per hr. It has established records of 777 tons per 8-hr turn, 2008 tons per day and 35,743 tons per month. It turns out angles $\frac{5}{8}$ x $\frac{5}{8}$ in. to 2 x 2 in., flats $\frac{1}{4}$ to $\frac{3}{4}$ in. thick $\frac{5}{8}$ x to 4 in. wide, rounds $\frac{3}{8}$ to $1\frac{3}{8}$ in. in diameter, squares $\frac{3}{8}$ to $\frac{25}{32}$ in., hexagons $\frac{3}{8}$ to $1\frac{3}{16}$ in., and some special shapes. Power consumption averages 39 kwhr per ton for the main drives, 4 kwhr for auxiliaries.

The 14-in. mill, first started in 1923, is a 10-stand layout, with six roughers in a continuous train followed by four 14-in. stands arranged in a cross-country double-duo.

Steel is furnished to the mill principally by the 24-in. billet mill in Plant No. 1, with some also coming directly from No. 1 blooming mill and from the 28-in. structural mill. The greater part arrives by rail, with some also coming by truck.

The billets may range from $3\frac{1}{2}$ to 6 in., 8 to 14 ft long. A typical billet is 5 in. square x 12 ft long, weighing 1000 lb.

Steel is heated in two 15 ft-9 in. x 38 ft side-charge, end-discharge furnaces. They are fired with fuel oil or coke oven gas under manual control, and use 3,250,000 Btu per ton heated. They provide a combined heating capacity of 50 tons per hr.

Billets are put into the furnace by a buggy charger carrying a ram.

They are moved through the furnace by a pusher and are discharged over the furnace drop-out by the pusher action.

Table VII gives general mill data. All of the stands are two-high, with twist guides to obtain edging passes. Roughing stands have babbited roll neck bearings, with composition bearings for the finishing rolls. Only top rougher rolls are adjustable vertically. Top rolls are adjustable in Nos. 7 and 8 finishing stands.

All adjustments are made by manually operated screws.

The entire mill is driven through line shaft and bevel gearing by a single 4750/2850-hp, 2200-volt 300/490-rpm induction motor arranged in a constant torque Kraemer set with a 1750-hp 480-volt d-c motor.

Mill pinions for No. 1 stand are 20-in. pitch diameter (alternate 18 in.), 20-in. face, 27 teeth. Stands Nos. 2, 3, 4, 5, and 6 have 18-in. pitch, 20-in. face, 25-tooth pinions. Finisher pinions are 14-in. pitch diameter, 15-in. face, 25 teeth.

Hydraulic sprays at 800-psi pressure are placed at the entry of Nos. 1, 8 and 10 stands and at the exit of Nos. 2, 7, and 9 stands.

From the last finishing stand, the steel is carried over the runout to a 300 ft x 61 ft-2 in. rack-type double hot bed. A roller straightener is installed at the delivery end of each side of the hot bed. The runouts proceed for another 300 ft to shears capable of cutting 16-sq in. sections, followed by scales.

Separate straightening machines for rounds, flats and shapes are also installed in the end of the mill building.

The 14-in. mill product includes 1½ to 4-in. angles, 3 and 4-in. beams, 3 to 5-in. channels, 3-in. Z-bars, ⅞ to 3 1/16-in. rounds, ⅞ to 2 in. squares, 1 3/16 to 3 1/16-in. hexagons, and flats ¼ to 2½ in. thick x 1½ to 6½ in. wide. Some special shapes are also produced.

Average rolling rate is 38 tons per hr, with established maximums of 710 tons per 8-hr turn, 1824 tons per day and 29,268 tons per month. The mill drives use 27 kwhr per ton rolled, the auxiliaries 4 kwhr per ton.

HOT STRIP MILLS

Quick to realize the possibilities of continuous wide strip mill, Inland installed a 76-in. mill in 1932. This unit was one of the first laid out in the basic pattern which was followed by subsequent installations throughout the industry. This was followed in 1938 by a second mill, a 44-in. continuous unit to complement the products from the 76-in. mill.

Both mills lie in line with their roughing ends toward each other with No. 3 blooming mill between them. No. 4 slabber is also nearby and its product goes to a common slab yard that serves both strip mills.

These mills, as well as all installations in Plant No. 2, are built on made land extending out into Lake Michigan. The fill was made with sand dredged from the lake bed and pumped into place in conjunction with cinder and granulated slag. Considerable piling was required to stabilize the concrete foundations for the mills.

76-in. mill—Slabs for the 76 in. may range 18 to 75 in. wide, 4½ to 6½ in. thick and 68 to 192 in. long. A typical average is 52 x 5¼ x 130 in. Slab weight averages 12,000 lb in a range of 3000 to 17,500 lb.

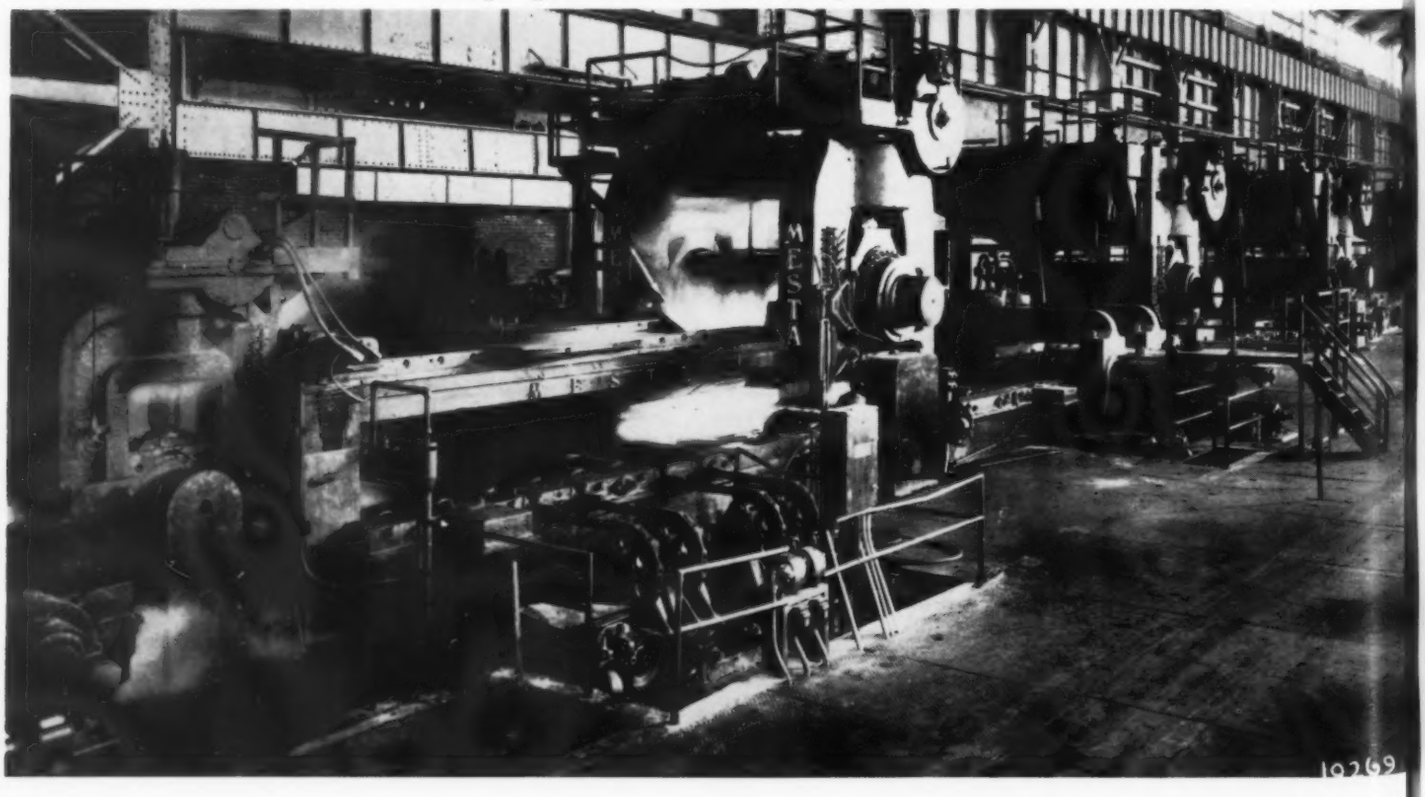
Cranes and transfer cars bring slabs to a magazine feeder which moves the slabs to the furnace charging table. This table is 120 ft long and runs across the charging ends of the furnaces. It is built in three sections, each driven by a 75-hp motor.

At each furnace there is a double head pinion and rack pusher. The heads on each furnace may be operated separately or together. Each head is driven by a 100-hp motor.

The three heating furnaces are of triple-fired design, 100 ft long overall, and rated at 110 tons per hr. Hearths are 18 ft wide and 92 ft long, of which 20 ft is a solid hearth soaking zone. Furnace roofs are flat suspended arches. The side walls are well insulated and the furnaces are encased with steel plate.

The furnaces are fired with coke oven gas and fuel oil in proportions of 0 to 60 per cent gas and 100 to 40 per cent oil. The main heating zones are underfired by

Roughing stands of the 76-in. hot strip mill.



five burners and overfired by five burners. The soaking zones are each fired by six burners. Total heat input to the three furnaces averages about 530,000,000 Btu per hr. Forced draft fans supply combustion air which is heated to 500 to 650 F in single-pass tile recuperators. Each furnace is well equipped with instruments, including three fuel input controls, three fuel-air ratio controls, three temperature controls and a furnace pressure control.

Heated slabs, expelled from the furnace one at a time by action of the furnace pushers, slide down discharge skids to the furnace table, where bumpers absorb the impact. Passing over the furnace and mill approach tables, the slab continues on through the mill. Table VIII gives some details on the mill stands.

On each side of the broadside stand there is a turntable which can be used to turn the slab through 90 degrees for cross rolling to increase width and then return it to its original axis. A slab pusher ahead of the broadside stand assists in entering the slab between the rolls. Following the broadside stand is a slab squeezer to square up the slab edges.

The slab then proceeds to the three remaining roughers. These stands are equipped with integral edging rolls on their entry sides. A 150-hp adjustable speed motor on top of each stand drives its edging rolls.

Preceding the finishing train is a crop shear for squaring up the ends of the breakdown if desired.

Between the finishing stands are loopers to take up slack in the strip between successive stands. They are operated by d-c torque motors.

All work roll necks operate in roller bearings. Backup necks of the roughing stands also run in roller bearings, with oil-film bearings on the finishing backup rolls.

To help improve finished strip surface, hydraulic descaling sprays are installed at the delivery side of both scalebreakers, the broadside stand, Nos. 3 and 4 roughers and the first finisher. Water for these sprays is provided by two 1000-psi, 2000-gpm centrifugal pumps.

Scale detached from the steel as it passes through the mill drops through the table into a trench below and is flushed away.

From the finishing train, the strip passes over the runout table to three downcoilers about 400 ft away. The table is composed of rollers individually driven by a-c motors under variable frequency control to give table speeds of 345 to 1380 fpm.

The coilers form coils 24 in. inside diameter, up to 54 in. outside diameter, and up to 72 in. wide. Coil weights average about six tons. Maximum weight is 350 lb per in. of width. Coils ejected from the coilers are moved by conveyor to a storage building nearby.

As steel passes through the mill, its temperature is checked by radiation pyrometers located at the broadside exit, at the entry and exit of the finishing train and at the coilers.

When the mill is rolling plate, the steel is removed from the runout table over chain type transfers to a parallel table line on each side of the runout. The transfers are about 258 ft long. The parallel tables are about 850 ft long and contain roller levelers, end shears, flying shears and pilers. Steel can be cut to lengths of 96 to 300 in. Another table along the east side of the mill contains a rotary side shear, a leveler and an end shear.

Finishing stands of the 76-in. hot strip mill.

Power for the finishing train drives is furnished by three motor-generator sets each consisting of two 2500-kw, 600-volt d-c generators driven at 500 rpm by a 7000-hp, 6600-volt synchronous motor. A 1500-kw mercury arc rectifier has been added here, all feeding into a common bus. The voltage has also been raised to 660 in order to obtain more driving power and speed.

The runout table draws power from six units, each consisting of a 15/60-cycle, 110/440 volt, 67/250 kva alternator driven by a 125-hp, 600 volt 260/1200-rpm d-c motor. These motors also draw power from the three large sets supplying the finishing drives.

Three special sets are installed to provide 250-volt d-c for the coiler motors.

The 76-in. mill is lubricated by three circulating oil systems and ten automatic grease systems. An oil system of 150-gpm circulation, 15,000-gal storage capacity serves the mill pinions. A 150-gpm, 16,000-gal oil system takes care of the reduction gear sets. A 200-gpm, 8050-gal system lubricates the backup roll bearings.

Two grease systems lubricate the work roll bearings. Other grease systems serve table rolls, hot bed chain drives, coilers, etc.

The 76-in. mill can produce No. 16 gage material in widths of 30 to 60 in., No. 14 gage up to 66 in. wide and No. 12 gage and heavier up to 72 in. wide. About 46 per cent of its product goes to hot rolled finished product, 56 per cent to cold rolled or galvanized product.

The mill averages 225 tons per hr, but has rolled as much as 2835 tons per 8-hr turn, 6197 tons per day and 153,000 tons per month.

Equipment for finishing hot rolled flat products is installed in the runout end of the hot mill buildings. This includes a 72-in. rotary shear, two 2-high skin

pass mills for sheet, three side-and-end shear units, a rotary slitter, two resquaring shears and a leveler.

44-in. mill—In general, the 44-in. mill rolls lighter gages than the 76-in. mill, and, of course, narrower. This mill rolls No. 18 gage in widths of 18 to 38 in. and heavier gages in 18 to 41-in. widths. No. 12 gage and heavier is rolled in 9 to 41-in. widths. The average product gage is 0.103 in.

Slabs for this unit average about 34 x 5 x 175 in., but may range from 9 to 43 in. in width, 4¼ to 6½ in. in thickness and 68 to 192 in. in length. Weights run 2000 to 14,000 lb, averaging about 9000 lb.

Slabs are handled in the same way as at the 76-in. mill, with cranes and transfer cars bringing them to two magazine feeders. The furnace charging table is 387 ft long and is driven by nine 50-hp motors.

The 44-in. mill is served by four continuous furnaces. They are 83 ft long overall, with hearths 76 ft-5 in. long, including an 18 ft-9 in. solid soaking hearth. Three of these are 18 ft wide inside, one is 24 ft wide. All have flat suspended roofs, are completely insulated and metal encased.

The furnaces are heated with fuel oil (91 per cent) and coke oven gas (9 per cent). The three narrower fur-

TABLE VIII
Hot Strip Mills

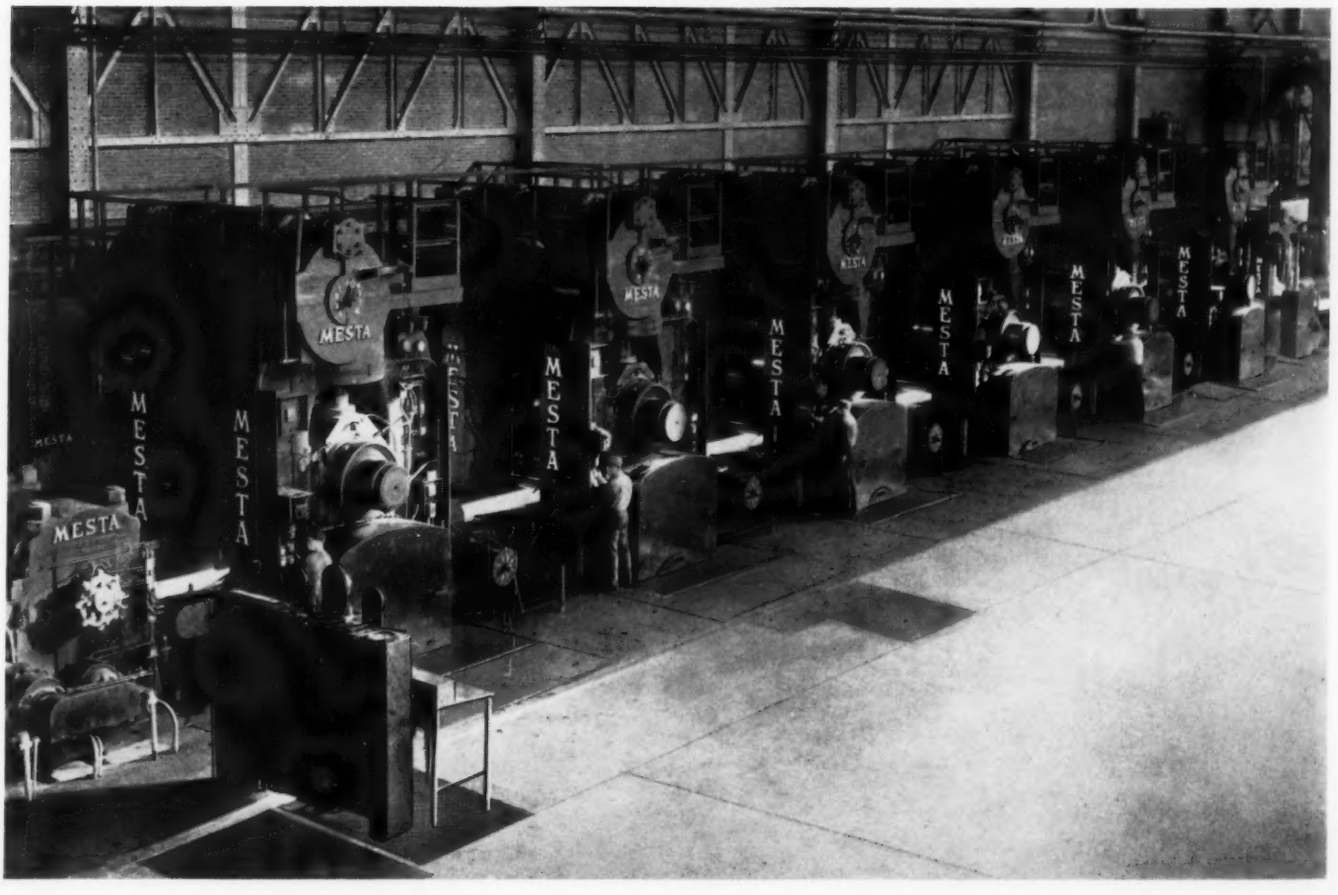
Stand	Two or four-high	Work roll		Backup roll		Distance from preceding stand, ft-in.	Motor data			Gear ratio	Roll, rpm	Roll face speed, fpm	Screw-down motors, No. & hp
		Diameter, in.	Body length, in.	Diameter, in.	Body length, in.		Hp	Voltage	Rpm				
76-in. hot mill													
No. 1 scale-breaker	2	40	79	..	..	..	2250	6600	293	24.0	12.2	128	(2) 25
No. 1 broadside	4	36	96	49	96	31-4	3000	6600	148	7.846	18.9	177	(1) 75
No. 2 rougher	4	25	79	49	76	40-11	4000	6600	247	7.8	31.6	206	(1) 75
No. 3 rougher	4	24	79	49	76	46-6	5000	6600	300	7.8	38.4	227	(1) 75
No. 4 rougher	4	24	79	49	76	70-6	5750	6600	375	7.8	48.0	376	(1) 75
No. 2 scale-breaker	2	23	79	..	..	98-11	500	600	150/450	8.87	16.9/50.7	106/318	(1) 10
No. 5 finisher	4	25	79	49	76	14-0	3500	660	175/350	6.33	27.6/55.2	180/360	(1) 75
No. 6 finisher	4	25	79	49	76	18-0	3500	660	175/350	4.0	43.7/87.5	290/580	(1) 75
No. 7 finisher	4	25	79	49	76	18-0	3500	660	175/350	2.95	59.4/118.8	390/780	(1) 75
No. 8 finisher	4	25	79	49	76	18-0	3500	660	175/350	2.29	76.4/152.8	500/1000	(1) 75
No. 9 finisher	4	25	79	49	76	18-0	3500	660	175/350	1.91	91.7/183.5	600/1200	(1) 75
No. 10 finisher	4	25	79	49	76	18-0	3500	660	175/350	1.66	105.4/210.8	690/1380	(1) 75
44-in. hot mill													
No. 1 scale-breaker	Vert.	42	16	..	..	..	(2) 300	440	500	28.57	17.5	183	(2) 50
No. 1 rougher	2	34	47	..	..	27-0	3000	6600	150	7.8	16.5	180	(1) 35
No. 2 rougher	4	21	47	42	44	39-9	2500	6600	375	7.8	48.0	272	(2) 35
No. 3 rougher	4	21	47	42	44	55-6	2500	6600	375	5.47	68.6	388	(2) 35
No 4 rougher	4	21	47	42	44	82-6	2500	6600	375	5.47	68.6	388	(2) 35
No. 2 scale-breaker	2	24	46	..	..	132-3	500	600	150/600	8.81	17/68	107/428	(1) 15
No. 5 finisher	4	21	47	42	44	14-8	2500	600	225/450	5.875	38.2/76.5	220/434	(2) 35
No. 6 finisher	4	22	47	42	44	18-0	2500	600	225/450	3.46	64.8/129.6	366/732	(2) 35
No. 7 finisher	4	22	47	42	44	18-0	2500	600	225/450	2.38	95/190	535/1070	(2) 35
No. 8 finisher	4	22	47	42	44	18-0	2500	600	225/450	1.84	122/244	685/1370	(2) 35
No. 9 finisher	4	22	47	42	44	18-0	2500	600	225/450	1.50	150/300	850/1700	(2) 35
No. 10 finisher	4	22	47	42	44	18-0	2500	600	225/450	1.27	177/354	1010/2037	(2) 35

View of 44-in. hot strip roughing stands, looking toward the heating furnaces.

naces, each rated at 80 tons per hr, are somewhat unusual, having four firing zones. Two zones follow the conventional pattern, with six burners firing into the top and six more burners underfiring the main heating zone. The third firing zone has six burners overfiring the main heating zone but in a reverse direction—that is, in the same direction as the steel moves. The soaking zone is overfired by eight burners, also reverse firing toward the discharge doors. Burner capacity on each furnace totals 200,000,000 Btu per hr.

The fourth furnace is of conventional design with six burners overfiring and five underfiring the heating zone,

The 44-in. hot strip finishing train has a maximum delivery speed of 2037 fpm.



and 10 burners overfiring the soaking zone. Burner capacity totals 240,000,000 Btu per hr. This furnace is rated at 100 tons per hr.

The three smaller furnaces have tile recuperators; the larger furnace has a metallic tube recuperator. Air for combustion comes from forced draft fans and is heated to 400 or 500 F. The smaller furnaces are operated manually, while the larger has three fuel input controls, three fuel-air ratio controls, four temperature controls and a furnace pressure control.

The furnaces heat about 80 tons of slabs per hr each, averaging about 2,400,000 Btu per ton. About 5 per cent of the slabs charged have some residual heat from the blooming operation.

At the discharge end of the furnaces, skid plates of special design eliminate excessive shock to the furnace table as the slabs, at temperatures averaging about 2250 F, are discharged from the furnace through action of the double head pushers on each furnace.

Details of the 44-in. mill train are set forth in Table VIII. It will be noted that the roughing scalebreaker on this mill is a vertical edger. Also, the first rougher is a two-high stand. There is no broadside stand, as slab spreading is unnecessary on the narrow mill. Hence, there are no turntables or slab squeezer. The delay table between roughing and finishing trains is somewhat longer than in the 76-in. mill.

No. 2, 3 and 4 roughers are of universal type, with vertical edger rolls 22 in. in diameter on the entry side, integral with the mill stand. Vertical rolls are driven by a 150-hp motor mounted on top of each stand and controlled to synchronize vertical roll speeds with main roll speeds.

A crop shear is installed at the entry of the finishing train to square off the ends of steel coming from the roughing train.

The delay table between roughers and finishers consists of 72 cast iron rollers, driven in pairs by 36 d-c shunt motors rated at 2 hp, 250 volt, 525 rpm under adjustable voltage control.

Loopers between successive finishing stands to take up strip slack are operated by 50-hp torque motors controlled from a 70-volt constant potential generator. Where two screwdown motors are applied to one stand, they may be operated individually or, through a magnetic clutch, in unison.

Hydraulic descaling sprays are installed at the entry sides of No. 1 rougher, delivery sides of No. 3 and 4 roughers, delivery side of No. 2 scalebreaker and entry sides of No. 5 and 6 finishers. The sprays are supplied by three 8-stage centrifugal pumps, each rated at 1000 gpm, 1000 psi.

The vertical edger rolls run in roller bearings. The two-high rougher is equipped with oil film roll neck bearings, as are the backup roll bearings in all four-high stands. All work rolls in the four-high stands operate in roller bearings.

At the delivery side of No. 10 finisher a flying shear is installed capable of cutting strip up to 40 in. wide x $\frac{3}{16}$ in. thick into lengths of 11 to 44 ft. It is driven by two 150-hp shunt motors. On strip to be coiled, the shear can be used to crop the ends.

An x-ray gage installed at the exit of No. 10 finisher checks strip gage.

The mill runout table extends approximately 335 ft to the coilers and then an additional 200 ft to a piler which handles cut lengths produced on the mill. The table is made up of cast iron rollers 12-in. in diameter x 54-in. body length on 18-in. centers. Each pair of rollers is driven by a 7½-hp, 250-volt, 1750-rpm d-c shunt motor operating under adjustable voltage control.

The two down-coilers handle strip up to 42 in. wide, forming coils 24 in. inside diameter and up to 48 in. outside diameter. Maximum coil weights are 350 lb per in. of coil width. Actual coil weight average 4.6 tons.

From the coilers, coils are moved to storage by a link

This new continuous pickling line in No. 3 cold mill supplements three other lines previously installed.

chain type conveyor containing a 90-degree lift-and-turn device. The conveyor consists of two chains 20 in. apart. It is in four segments, each separately driven by a 35-hp motor. The bend is handled by individually driven rollers. A second lift-and-turn at the end of one conveyor directs coils to a 720-ft roller chain conveyor which carries them to a cold reduction mill.

Steel temperature in the mill is recorded by radiation pyrometers located at the delivery side of No. 2 rougher, at the entry side of No. 2 scalebreaker, at the delivery of No. 10 finisher and just ahead of the coilers.

The four roughing stands are driven by synchronous motors. The finishing stand drives operate under adjustable voltage control, drawing power from two motor-generator sets. Each set consists of two 2500-kw, 600-volt, d-c generators, one 1000-kw, 250-volt d-c generator and one 500-kw exciter, all driven by a 10,000-kw, 6600-volt, 25-cycle synchronous motor.

These units, together with special sets for the delay table, runout table, coilers, loopers, excitations, etc., are housed in the hot mill motor room. Electrical machinery is cooled by drawing air from the motor room down through the units, through surface type air coolers, and returning it to the room.

Power consumption of the 44-in. mill runs 44.5 kwhr per ton for the main drives and 7.8 kwhr per ton for hot mill auxiliaries.

The 44-in. mill averages about 240 tons per hour. Approximately 28 per cent of the product goes into hot rolled finished, 52 per cent into full finished, and 20 per cent into tinplate. The mill has set records of 2673 tons per 8-hr turn, 7088 tons per day and 158,284 tons per month.

Hot finishing equipment provided in the 44-in. mill building includes a 26 x 56-in. skin pass mill driven by a 250-hp d-c motor, two 48-in. side trimming, leveling and cut-up lines, and three circle shears. In another hot finishing department nearby there is a 27 x 60-in. skin pass mill driven by a 175-hp motor, a batch pickler with scrubber and dryer, and two cut-up lines. There is also a gas-fired continuous normalizing furnace 9 ft wide x 106 ft long.

STRIP AND SHEET FINISHING

Strip and sheet material is cold finished in several separate areas. No. 1 and No. 2 cold mills and the tin plate department are adjacent and lie to the west of the hot strip mills. They contain three continuous pickling lines, a 72, a 54 and a 42-in. tandem cold mill, a reversing cold mill, cleaning and annealing facilities, temper mills, tinning equipment and shearing lines. No. 3 cold mill is located on the east side of the hot mills and contains a pickling line, a 56-in. tandem cold reduction mill, annealing furnaces, a 56-in. temper mill, shearing facilities and a continuous normalizing line.

At No. 1 cold mill, three continuous pickling lines handle strip in widths of 18 to 72 in. At No. 3 mill, the single pickling line handles widths of 18 to 63 in. All lines can handle gages of 0.06 to 0.185 in.

All of the lines are of conventional design, with four acid solution tanks, followed by a rinse tank, a scrubber, dryer and a recoiler. The tanks are built of steel plate, lined with rubber and acid-resisting brick. Each tank has a steel plate cover, rubber lined, and is vented through rubber-lined ducts and fans. Pickling solutions contain from 6 to 16 per cent sulphuric acid in the various tanks, and are maintained at 200 to 210 F by steam under automatic control. Coils are butt-welded together to form a continuous strand.

This 19½- in. and 49-in. x 42-in. tandem cold mill, with a maximum delivery speed of 4340 fpm, processes strip 18 to 37 in. wide, principally in tinplate gages.

Table IX gives some details of the four pickling lines.

A four-arm vertical-mast batch pickler for cut lengths is installed in No. 1 cold mill. It is followed by a scrubbing and drying unit.

Pickled strip is cold rolled in the four tandem mills and the reversing mill listed in Table X. The normal reduction in cold rolling is about 60 per cent.

The 72-in. mill is a three-stand unit which handles strip 18 to 72 in. wide. It has a monthly capacity of 50,000 tons. The drives of this mill receive power from three separate 1250-kw d-c motor-generator sets.

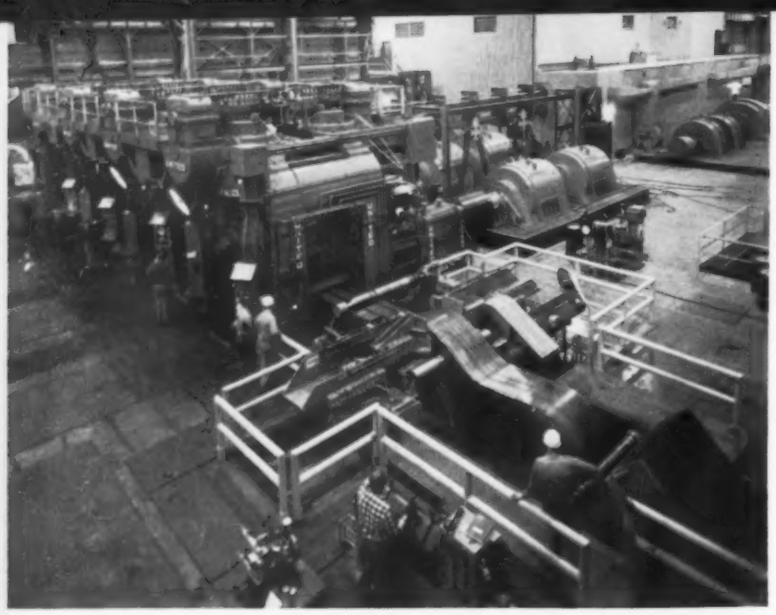
The 54-in. mill has four stands. It rolls strip 18 to 50 in. wide, and has a capacity for 42,000 tons per month. Its drive motors draw power from two motor-generator sets providing a total of 4500 kw of generator capacity.

The 42-in. mill, with five stands, takes strip 18 to 37

TABLE IX
Continuous Pickling Lines

No.	1	2	3	4*
Nominal size, in.	74	74	60	63
Over-all length, ft	630	630	715	780
No. of pickling tanks	4	4	4	4
Tank length, ft	(3) 70; (1) 60	(3) 70; (1) 60	80	(2) 85-6; (2) 84
Tank width, ft-in.	9-4	9-4	8-2	9-11
Tank depth, ft-in.	5-2	5-2	5-2	6-7
Tank capacity, gal each	(3) 12,240 (1) 10,440	(3) 12,240 (1) 10,440	12,168	37,800
Speed range, fpm	150/350	150/350	150/400	800 maximum
Capacity, tons per month	← 148,500 →			45,000

* At No. 3 cold mill.



This new four-stand tandem cold mill, a 21-in. and 56-in. x 56-in. unit, has a monthly capacity of 60,000 tons of strip in widths of 18 to 52 in.

This new 22½-in. and 56-in. x 56-in. coil temper mill operates at speeds up to 3500 fpm.

in. wide. Its monthly capacity is 42,000 tons. Two motor-generator sets provide 12,000-kw generator capacity to feed the mill drive motors.

The 56-in. mill, located in No. 3 cold mill, is a four-stand unit installed in 1958. This mill is served by an entry coil conveyor, a coil lowering device, a coil rotating rig, a coil box and pinch roll unit.

The mill stands have cast steel, closed top housings, bolted together top and bottom. Each housing post has an area of about 1100 sq in. The top work roll is hydraulically balanced by cylinders in the bottom work roll chocks. The top backup roll is hydraulically balanced by cylinders in the legs of the bottom backup chocks. The rolls are adjusted by forged steel screws 18 in. in diameter operating in bronze screw boxes. The screws are driven by two 100-hp d-c motors through double reduction spur and worm gearing. A magnetic clutch connecting the two motor shafts permits operation individually or in unison. Screwdown motors operate under adjustable voltage control.

The wedge-type reel, expanded and collapsed hydraulically, forms coils of 24 in. inside diameter.

Auxiliaries at the delivery side of the mill include a reel stripper, a belt wrapper, coil upender and delivery conveyors.

The main drives of the 56-in. mill draw power from two motor-generator sets with five 600-volt d-c generators of 16,680 kw total capacity. Each set is driven by a 12,000-hp, 514-rpm, 13,800-volt synchronous motor.

The 56-in. mill provides a monthly capacity of 60,000 tons of strip in widths of 18 to 52 in. In designing this unit, provisions were made to permit widening to 66 in. should it become desirable.

This mill is equipped with a dual roll coolant system applicable to the rolling of tinplate and sheet gages. The system allows the use of palm oil solution for tinplate gages, and almost any combination of soluble oil, water and other rolling oils for sheet gages. Fog from the mill is collected by a down-draft exhaust system with fans and eliminators placed in the basement below the mill floor.

Coil annealing is done in 25 portable cover, radiant-tube furnaces with 75 bases. These covers range 29 to 35 ft long, 12 ft-6 in. to 18 ft-6 in. wide, and 5 to 13 ft high. They are fired with coke oven gas under automatic temperature controls. Most of the product is annealed in coil form, at temperatures of 1100 to 1300 F. Cycles run 36 to 48-hr heating, a 3-hr soaking and 36 to 48-hr cooling. These furnaces provide a monthly capacity for 70,000 tons. Three 50,000-cu-ft-per-hr gas machines provide protective atmosphere during annealing.

Additional batch annealing capacity for 45,000 tons per month is provided in the No. 3 cold mill. This installation consists of 12 four-stack covers 36 ft-10 in. long x 10 ft-4 in. wide, and four single-stack covers 11 ft-2 in. in diameter. Each cover has three bases. The large furnaces take 12 to 16 coils, with charges averaging about 170 tons. Temperatures usually approximate 1300 F, with cycles running about 18-hr heating, 20-hr soaking and 50-hr cooling.

Protective atmosphere for these furnaces is supplied by four gas-generating machines, each of 20,000-cu ft per hr capacity.

A 400-ft gas-electric normalizing furnace is also installed in No. 3 cold mill. The furnace operates at speeds up to 125 fpm and has a capacity of 360 tons per day.

After annealing, sheet material may be given a skin pass in the temper mills listed in Table X. All of these are located on the west side of the hot strip mills except the last item, a 56-in. coil temper mill, which is in No. 3 cold mill. This mill went into operation in 1958.

Like the tandem mill in the same department, the temper mill is designed to permit widening to 66 in. if so desired in the future. As far as possible, temper mill equipment duplicates that of the 56-in. tandem mill to simplify the spare part problem. The drives of the 56-in. temper mill are supplied with d-c power by a motor-generator set of 2590-kw capacity, driven at 514 rpm by a 2000-hp, 2300-volt synchronous motor.

TINPLATE DEPARTMENT

Stock for tinplate is cold rolled principally on the 42-in. tandem mill in coils built up at the pickler to a maximum of 30,000 lb. After cold rolling, this material

TABLE X
Cold Reduction Mills

Stand	Two- or four-high	Work roll		Back up roll		Distance from preceding stand, ft-in.	Motor data		Rpm	Gear ratio	Roll, rpm	Roll face speed, fpm
		Diameter, in.	Body length, in.	Diameter, in.	Body length, in.		Hp	Voltage				
72-in. Tandem mill												
No. 1	4	20½	74	44	71	...	1625	750	500/1000	10.1	49.5/99	266/532
No. 2	4	20½	74	44	71	16-0	1625	750	500/1000	7.1	70.5/141	379/758
No. 3	4	20½	74	44	71	16-0	1625	750	500/1000	5.4	92.5/185	497/994
Reel	...	...	..	..	..	10-4	400	600	250/1200	7.16	...	...
54-in. Tandem mill												
No. 1	4	20½	54	44	54	...	1410	680	450/900	10.1	44.5/89	239/478
No. 2	4	20½	54	44	54	16-0	1410	680	450/900	7.1	60.5/121	325/650
No. 3	4	20½	54	44	54	16-0	1700	680	450/900	5.4	83/166	546/891
No. 4	4	20½	54	49	54	16-0	1410	680	450/900	3.87	116/232	624/1250
Reel	..	...	..	..	..	10-4	400	680	250/1200	4.71	...	...
42-in. Tandem mill												
No. 1	4	19½	42	49	42	...	1600	600	100/350	Direct	100/350	511/1790
No. 2	4	19½	42	49	42	13-0	3000	600	200/500	Direct	200/500	1020/2550
No. 3	4	19½	42	49	42	13-0	3000	600	300/600	Direct	300/600	1530/3060
No. 4	4	19½	42	49	42	13-0	3000	600	400/770	Direct	400/770	2040/3930
No. 5	4	19½	42	49	42	13-0	3000	600	500/850	Direct	500/850	2550/4340
Reel	..	...	..	..	..	10-8	800	600	250/1200	Direct	...	...
*56-in. Tandem mill**												
No. 1	4	21	56	56	56	...	3000	600	100/300	Direct	100/300	550/1650
No. 2	4	21	56	56	56	15-0	5000	600	150/425	Direct	150/425	826/2340
No. 3	4	21	56	56	56	15-0	6000	600	250/625	Direct	250/625	1375/3440
No. 4	4	21	56	56	56	15-0	6000	600	250/625	Direct	250/625	1375/3440
Reel	..	...	..	..	..	...	1200	600	175/612	Direct	...	...
Reversing mill	4	12½	39	34	38	...	1800	600	200/400	Direct	200/400	656/1310
Reels							(2) 166	250	200/450	4.44	45/101	...
Coil temper mill	2	30	62	..	..	...	800	600	200/400	Direct	200/400	1570/3140
Reel							800	600	125/350	Direct	125/350	
Coil temper mill	4	20½	74	44	71	...	800	600	200/400	Direct	200/400	1075/2150
Reel							800	600	125/350	Direct	125/350	
Coil temper mill	4	20½	74	44	71	...	800	600	200/400	Direct	200/400	1075/2150
Reel							800	600	125/350	Direct	125/350	
Sheet temper mill	4	20½	74	44	71	...	125	230	250/900	14.09	17.75/63.8	95.5/343
Sheet temper mill	2	27	56	..	..	...	125	230	250/900	12.19	20.5/73.7	145/523
Tin temper mill	4	18	40	39	40	...	400	400	0/1360	6.136	0/222	0/1044
Reel							90	300	360/1200	4.85	74/246	
Tin temper mill	4	18	40	30	40	...	400	400	0/1360	6.136	0/222	0/1044
Exit tension							400	400	0/1360	5.33	0/255	
Reel							90	300	36/1200	4.85	74/246	
Tin temper tandem												
Entry tension							400	300	575/1150			
Stand no. 1	4	18	42	39	42	...	(2) 250	600	250/500	Direct	250/500	1180/2360
Stand no. 2	4	18	42	39	42	11-0	(2) 400	600	575/1150	Direct	575/1150	2710/5440
Exit tension							400	300	575/1150			
Reel							250	600	250/875	Direct	250/875	
*Coil temper mill**	4	22½	56	56	56	...	(2) 500	600	500/1000	1.68	297/595	1750/3500
Reel							1200	300	175/612	Direct	175/612	

* Located in No. 3 cold mill.

is either put through a continuous annealing line in which is incorporated an alkaline cleaning unit, or it is put through a continuous electrolytic cleaning line and subsequently batch annealed.

The continuous annealing line is a 38-in. unit, 266 ft in over-all length. Strip is fed from a payoff reel and passes through a shear, an electric welder, tension rolls and a looping tower which stores up about 700 ft of strip. The cleaning ection of the line subjects the strip to a 190 F caustic solution.

The strip is next washed and dried, and then fed in vertical passes through a preheating zone and a gas-fired furnace. Strip next passes through a soaking zone (1200 to 900 F) and a water-cooled zone which reduces strip temperature to about 550 F. Protective atmosphere for the soaking and cooling zones is provided by two gas-conditioning machines.

The strip is finally quenched with water, dried and recoiled.

This line operates at speeds of 500 to 850 fpm, and processes material 18 to 36 in. wide and 0.007 to 0.018 in. in gage. Coils are 16 in. inside diameter and 72 in.

Two electrolytic tinning lines of alkaline type provide capacity for 22,607 tons of tinplate per month.

maximum outside diameter, in weights up to 30,000 lb. Production averages 21.7 tons per hr.

Black plate not put through the continuous anneal line is put through an electrolytic cleaning line which runs at speeds of 250 to 2500 fpm. This unit can handle strip in widths of 18 to 42 in. and gages of 0.007 to 0.0325 in. Coil weights may run up to 1000 lb per in. of width. This unit averages 36.6 tons per hr. After this cleaning, coils may be annealed in five gas-fired, radiant-tube portable annealing covers. Coils are moved to and from these furnaces by conveyors.

After black plate coils have been annealed, they are put through one of the three tin temper mills listed in Table X, and are then ready for coating.

Electrolytic tinplate is produced by two continuous lines. They are of the alkaline type. Each line contains payoff reels, crop shear, welder, looping tower, side trimmer, contact micrometer, pickling section, plating tank, rinse tank, fusion furnace, quench tank, chemical treatment unit, oiler, pinhole detector, shear and classifier.

No. 1 plating line handles strip in gages ranging 0.007 to 0.0145 in., with widths averaging about 30 in. Coils run up to 15,000 lb maximum weight. With a speed range of 400/750 fpm, this line generally operates at about 600 fpm with 65,000-amp plating current for 0.25 lb coating. Production averages 17.7 tons per hr.

No. 2 line can process the same gages. It operates at approximately 750 fpm with a plating current of 120,000 amp for 0.25-lb coating. Over-all speed range is 400/900 fpm. Production averages 20 tons per hr.

The two lines provide capacity for 22,607 tons of tin plate per month.

To reprocess mender sheets from the electrolytic lines, there are four 75-in. hot dip tinning units.

An expansion project recently authorized for the tinplate department includes a new continuous annealing line, a new temper mill and a new electro-tinning line with dual finishing facilities to deliver either coils or cut lengths.

GALVANIZING DEPARTMENT

Galvanizing facilities, which are located in Plant No. 1, consist of three continuous lines. Coils are brought from the strip mills in Plant No. 2 by tractor trailers.

Table XI gives some details of the three lines, which

TABLE XI
Galvanizing Lines

	No. 1	No. 2	No. 3
Year installed—	1951	1954	1955
Over-all length, ft-in.	888-6¼	887-3⅝	1035-10⅞
Length, oxidizing furnace, ft	20	20	30
Length, reducing furnace, ft	104	104	121
Length, controlled cooling zone, ft	224	224	261
Length, final cooling zone, ft	55	55	72
Gages handled	12/30	8/30	14/30
Widths handled, in.	24/48	24/48	24/60
Maximum coil weights entering, lb	30,000	30,000	40,000
Maximum coil weights leaving, lb	15,000	15,000	15,000
Maximum strip speed, fpm	225	225	300
Tons per hr	9.5	16.0	20.0

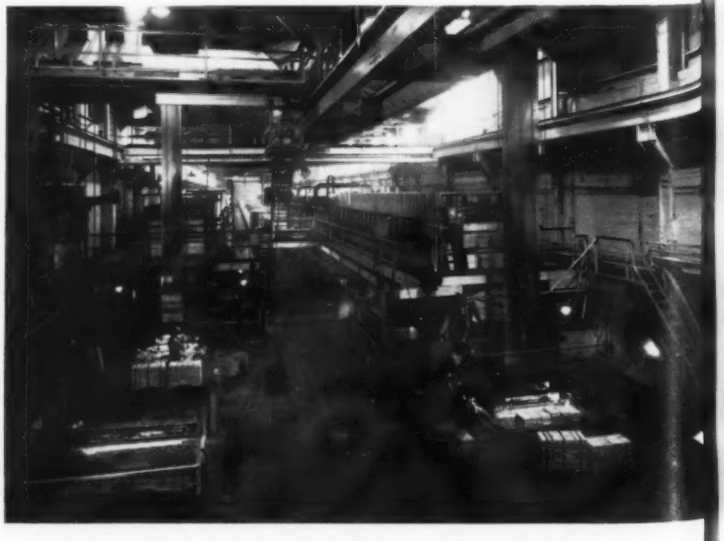
are basically similar in design and operation. Strip is fed from an uncoiling reel through a leveling unit to a double-cut shear which squares up the strip ends for welding. To permit uniform strip travel through the coating section during stoppages of the strip for welding the ends together, a horizontal storage loop is maintained by a loop-car which travels beneath the furnaces.

The strip first passes through an oxidizing furnace maintained at 850 to 900 F, where oil is burned off the strip surface. Next comes a reducing furnace, where a reducing atmosphere acts to remove surface oxide. This heating zone ranges 1500 to 1800 F in temperature, and is followed by a controlled cooling zone where strip temperature is reduced to 1200 to 1400 F and a final cooling zone where the temperature is further reduced to about 900 F.

Strip next passes through a zinc pot and coating rolls. The molten zinc adheres to the strip surface. Coating weights may range from 0.5 to 3.0 oz per sq ft of strip surface.

Forced air cooling ducts bring the strip temperature down to about 125 F. The strip then passes through a roller leveler, a second horizontal storage loop, a sodium silicate spray, a heater and chromic acid spray, and another leveler. Strip may then be recoiled or put through a shear and inspection line. Cut lengths up to 204 in. are possible.

This view shows two of the three continuous galvanizing lines which can galvanize about 30,000 tons of strip per month.



Miscellaneous finishing equipment here includes shears, slitters, levelers, and machines for corrugating sheets and bending culvert stock.

Departmental capacity is about 30,000 tons per month.

QUALITY CONTROL

Quality control is a function on which some 575 people work. A customer service department processes all incoming orders, reviewing the application of the steel ordered and specifying the procedure to be used in making and handling the steel. This department also acts as sales liaison in customer contacts.

The chemical department, in a main laboratory and auxiliary laboratories in Plants No. 1, 2 and 3 and at the tin mill, runs some 2,000,000 analyses a year for the various production processes. Three spectrographs provide rapid service for the open hearth departments.

The metallurgical department watches over all steps in production procedure. Inspectors at the open hearths oversee the actual steelmaking processes. Observers check primary and finish rolling to insure adherence to outlined practice. Inspectors look over all finished products for surface quality and tolerance limits. The main metallurgical laboratory is equipped to run metallographic and physical tests, including effects of heat treatment, etc. Auxiliary testing stations are provided in the various producing areas of the plant.

UTILITIES AND SERVICES

The electric power system for the plant is in two sections: a 25-cycle section and a 60-cycle section. The 25-cycle power is supplied entirely by generation within the plant. This system has a total generating capacity of 150,500 kw, divided between three stations. Characteristics of these generators are as follows:

No. 1 station—Two 5000-kva, 0.8-power factor, 2300-volt, 25-cycle, 1500-rpm, 180-psi steam pressure, 150-F superheat, 8500-sq ft surface condenser, 14 lb of steam per kwhr.

One 12,500-kva, 0.8-power factor, 2300-volt, 25-cycle, 1500-rpm, 200-psi steam pressure, 200-F superheat, 15,000-sq ft surface condenser, 12.5 lb of steam per kwhr.

No. 2 station—One 12,500-kva, 0.8-power factor, 2300-volt, 25-cycle, 1500-rpm, 275-psi steam pressure, 200-F superheat, 15,000-sq ft surface condenser, 12 lb of steam per kwhr.

Two 12,500-kva, 0.9-power factor, 2300-volt, 25-cycle, 1500-rpm, 275-psi steam pressure, 200-F superheat, 15,000-sq ft surface condenser, 12 lb of steam per kwhr.

Three 25,000 kva, 0.8-power factor, nominal 6900-volt, 25-cycle, 1500-rpm, 270-psi steam pressure, 625-F steam temperature, 30,000 sq ft surface condenser, 10.5 lb of steam per kwhr.

No. 3 station—Two 12,500-kva, 0.8-power factor, nominal 6900-volt, 25-cycle, 1500-rpm, 275-psi steam pressure, 200-F superheat, 15,000-sq ft surface condenser, 12 lb of steam per kwhr.

Two 12,500-kva, 0.8-power factor, nominal 6900-volt, 25-cycle, 3600/750-rpm (geared), 280-psi steam pressure, 650-F steam temperature, 15,000-sq ft surface condenser, 10 lb of steam per kwhr.

Single line diagram of Indiana Harbor works power system.

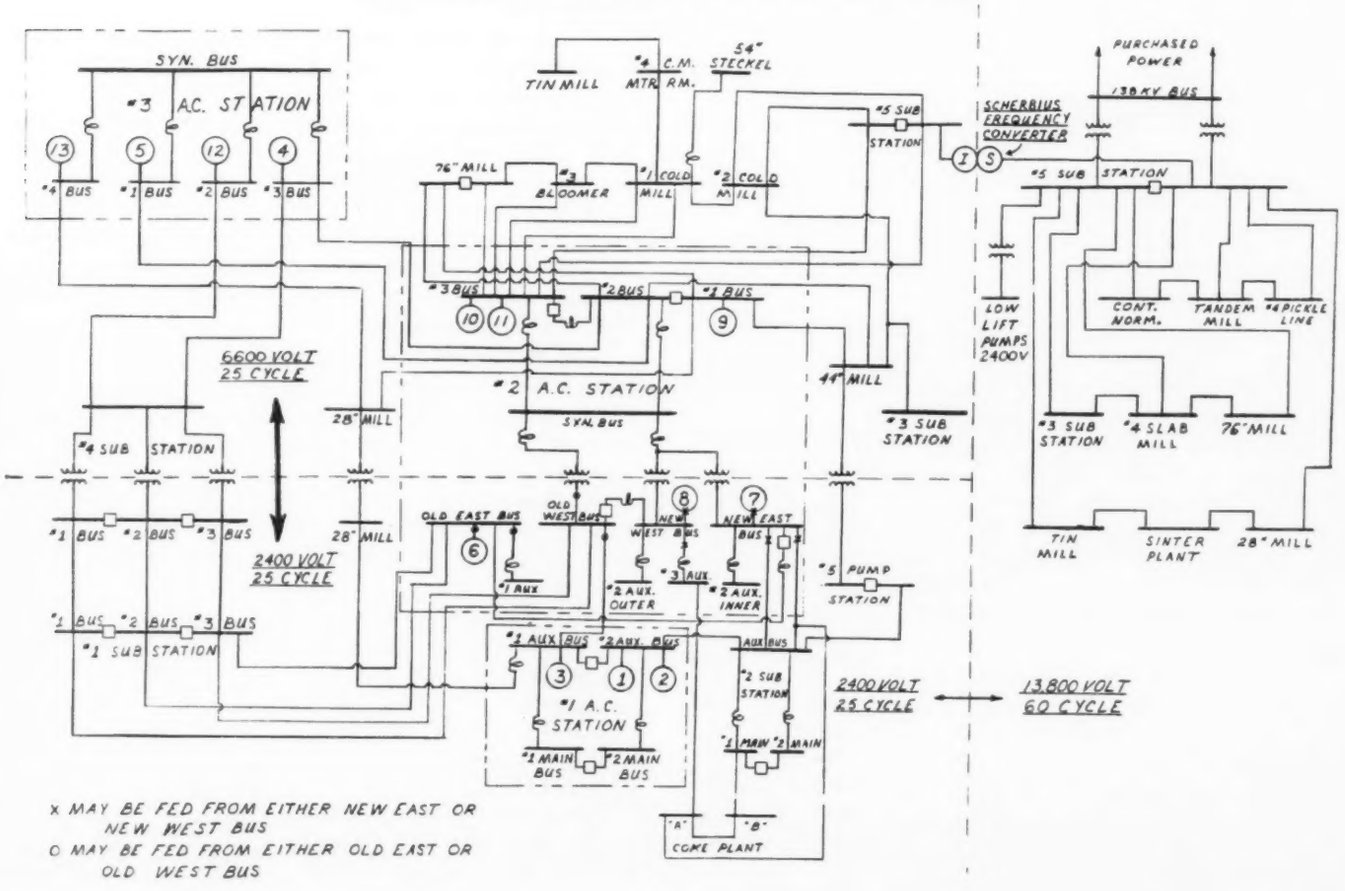


TABLE XII
Boiler Data

Station	No. of boilers	Steam pressure, psi, gage	Steam temperature, F	Capacity, lb per hr each	Kind of fuel	Combustion equipment
No. 1	2	225	597	50,000	Coke breeze, coal	Chain grate stokers
	4	225	597	50,000	Coal, coke oven gas	Underfeed stokers
No. 2	4	300	672	100,000	Blast furnace gas,* pulverized coal	Combination burners
	2	300	622	50,000	Blast furnace gas*	.....
	2	300	672	200,000	Blast furnace gas,* pulverized coal	Combination burners
	1	311	650	200,000	Blast furnace gas,* pulverized coal	Combination burners
	1	311	650	200,000	Blast furnace gas,* pulverized coal	Combination burners
	3	375	650	250,000	Blast furnace gas,* oil	Combination burners
No. 3	4	350	700	175,000	Blast furnace gas,* oil, coke oven gas	Combination burners
	1	375	700	200,000	Blast furnace gas,* oil, coke oven gas	Combination burners
No. 1 open hearth	12	200	448	12,500	Waste heat, water tube	.....
No. 2 open hearth	10	225	597	13,700	Waste heat, water tube	.....
	14	225	597	15,300	Waste heat, fire tube	.....
No. 3 open hearth	4	250	448	25,000	Wast heat, water tube	.....
	3	250	520	56,000	Waste heat, oil, water tube	Oil controlled manually
No. 3 blooming mill	5	225	397	16,400	Wast heat, oil, fire tube	Oil controlled manually
	1	250	406	32,000	Waste heat, fire tube	.....
No. 4 slabbing mill	6	260	514	30,000	Waste heat, oil	Oil and coke oven gas, controlled automatically

* Blast furnace gas may be enriched with natural gas.

The 25-cycle power is distributed at 2300 volts and 6900 volts, with connections between the two voltages through transformer banks to form an integrated system. The 2300-volt power is used principally in Plant No. 1 and in the older mills of Plant No. 2. The 6900-volt power is used in the newer mills.

This system has recorded instantaneous peaks of 160,000 kw and consumes an average of 115,000 kw, or about 75,000,000 kwhr per month.

The 60-cycle section uses power purchased from the utility company serving the area. This power enters the plant over two separate 138,000-volt lines from two power company stations and comes into a 138,000-volt bus at the transformer yard at No. 5 substation, which is located on the east side of the plant near the lake. Two 138,000/13,800-volt transformers rated at 15/20/25,000 kva supply the 13,800-volt distribution bus at this station. Power is distributed at 13,800 volts to the load centers on the 60-cycle section.

The 25-cycle and 60-cycle systems are tied together through a Scherbius frequency converter of the following characteristics:

Synchronous machine—15,000-hp, 514-rpm, 0.8-power factor, 13,800-volt, 15,000-kva, three-phase, 60-cycle.

Induction machine—16,800-hp, 15,000-kva, 514-rpm, nominal 6900 volt, three-phase, 25-cycle.

At present, a 30-minute demand of 32,000 kw is maintained on the utility company. The frequency converter regulates this demand by converting power in either direction as the load on the 60-cycle system varies.

The 60-cycle section has reached instantaneous peaks of 45,000 kw. The average 30-minute demand is 32,500 kw. There is also an optional 20,000 kw available from the utility during surplus power hours. Approximately 22,000,000 kwhr are purchased per month.

The total plant system sets up an average load of 150,100 kw. Plant consumption totals about 96,000,000 kwhr per month.

Steam for all plant usage is produced in eight boilerhouses containing 79 units. Some characteristics of the boilers are given in Table XII. The stations have capacities as follows:

	Lb of steam per hr
No. 1 station (Plant No. 2)	300,000
No. 2 station (Plant No. 2)	2,050,000
No. 3 station (Plant No. 3)	900,000
No. 1 open hearth (Plant No. 1)	150,000
No. 2 open hearth (Plant No. 2)	350,000
No. 3 open hearth (Plant No. 2)	268,000
No. 3 blooming mill (Plant No. 2)	115,000
No. 4 blooming mill (Plant No. 2)	180,000
Total	4,313,000

Inland uses waste heat for steam generation to an unusual degree, obtaining approximately 1,000,000 lb of steam per hr from this source.

No. 1 station supplies steam to the turbogenerators there and puts surplus into the 200-psi general plant system, which also receives all steam generated by the waste heat units. No. 2 and No. 3 stations produce steam principally for the turbogenerators and blast furnace blowers in the respective stations, but can also feed into the general plant system. Thus, all boilers are tied into the general system.

Total steam generation during winter months averages about 2,000,000,000 lb per month. Of this, about 38 per cent is used for power generation, 15 per cent for providing wind to the blast furnaces and the remainder for plant processes and heating.

No. 2 and 3 stations operate on 10 to 25 per cent makeup. At No. 1 station makeup runs as high as 60 per cent. All other boiler houses operate on 100 per cent makeup.

Lake Michigan is the source of water for Inland's plant. The principal entry is a forebay on the east shore of the plant, maintained 3 to 5 ft above the lake level by eight 100,000-gpm, 7.5-ft head pumps, each driven by a 300-hp, 2300-volt motor. These pumps were necessitated by periods of low lake level. Electric screens are installed at the entrance of the forebay to repel fish.

Three intakes on this forebay normally supply the plant's requirements. Through one intake water flows to No. 1 pump station nearby. Another intake connects

to an underground tunnel, 13 ft square and 200 ft below ground level, leading first to No. 2 pump house 2800 ft away at the other side of the plant, and then 5100 ft further to No. 3 power station at the south end of the plant. The third intake from the forebay consists of two 8-ft diam pipes leading to No. 5 pump station near the strip mills.

There is another point where water can be drawn into the plant system at No. 2 pump house, but this entry is not normally used, being located near the mouth of the canal where the water is not as desirable as fresh lake water.

There are, in essence, two water systems. The circulating water system, which is maintained at 10-psi pressure, supplies the surface condensers in the power stations. Service water at 50-psi pressure is used for processing and cooling throughout the plant.

No. 1 pump station supplies circulating water to No. 1 power station and service water to Plant No. 2. At the power station, circulating water passes through the condensers and flows to an open ditch from which a 20,000-gpm pump puts it into the service water system for Plant No. 2. No. 1 pump station has five motor-driven pumps of 48,000-gpm total capacity which send circulating water only to No. 1 power house, and six motor-driven pumps totaling 130,000-gpm capacity on service water.

At No. 2 pump station, circulating water is pumped to No. 2 power station and service water to Plant No. 2. Here, also, the circulating water is used in condensers and then repumped into Plant No. 2 service water. Circulating water pumps here include seven pumps (four motor-driven, three turbine-driven) with a total capacity of 240,000 gpm. Two turbine-driven pumps totaling 40,000-gpm capacity pump service water.

At No. 2 power station there are two motor-driven 30,000-gpm pumps on circulating water and seven pumps (three motor-driven, four with dual drives) of 121,000-gpm total capacity on service water.

At No. 3 power station, water rises out of the underground tunnel into a large sump, from which circulating water for the power station and service water for Plants No. 1 and 3 are pumped. Circulating water is handled here by four pumps (two motor-driven, two turbine-driven) of 140,000-gpm total capacity. Four 20,000-gpm pumps (two motor-driven, one turbine-driven, one with dual drive) handle service water.

No. 5 pump station, with six 20,000-gpm motor-driven pumps, supplies service water to the hot and cold strip mills.

At No. 1, No. 2 and No. 5 pump stations and at No. 3 power station, there are traveling, endless-belt screens to remove foreign matter.

Total installed pumping capacity is 488,000 gpm on circulating water, 511,000 gpm on service water. Approximately 760,000,000 gal of water are pumped from the lake each day. Of this, 475,000,000 gal per day of lake water go to the circulating water system. The other 285,000,000 gal of lake water, plus 170,000,000 gal of water from the circulating system, supplies the service water, totaling 455,000,000 gal per day.

Water for boiler feed is softened in eight separate treating plants, one for each boiler center. No. 3 station has a continuous hot lime-and-soda plant of 200,000 lb per hr capacity. No. 2 station and No. 4 slabbing mill each have a hot continuous lime and zeolite plant, rated at 650,000 and 225,000 lb per hr, respectively.

The main roll shop contains 22 roll lathes of various types and sizes, as well as some other machine tools.

All other boiler water is treated internally by chemicals fed from proportioners rated at 150,000 to 400,000 lb per hr.

Total water treated per month runs about 1,000,000,000 lb per month.

Compressed air for Plant No. 1 is supplied by seven compressors located in No. 3 pump house. Plant No. 3 is supplied from five compressors in No. 3 power house. In Plant No. 2, compressors are installed at six separate locations. Those in No. 1 power house, No. 2 power house, No. 2 substation and the 10-in. mill are tied together in a common system, as are those at the 76-in. mill, No. 3 substation, No. 5 pump house and No. 3 cold mill.

Maintenance is carried out on a departmental basis, backed by a complete layout of well-equipped shops centered chiefly in Plant No. 1. Here are the machine, blacksmith, pattern, carpenter, locomotive, welding, boiler, fabricating, rigger, pipe, scale and electric shops. A shop for repairing cars and mobile equipment is located in Plant No. 2. Refractory maintenance is performed by a masonry department of 200 to 300 men.

In general, all maintenance work is of a preventive nature, following carefully planned schedules to avoid breakdowns. This has resulted in holding lost operating time to a minimum.

The plant contains somewhat more than 100 miles of railroad track. Motive power consists of thirty-two 600-hp and eleven 1200-hp standard gage diesel-electric locomotives, two 500-hp and six 450-hp narrow gage diesel-electrics, and one 340-hp narrow gage diesel. Locomotives are dispatched by radio from yardmasters' offices.

Other mobile equipment includes 16 diesel locomotive cranes of 40 to 80-ton ratings, two 40-ton steam cranes, eight caterpillar diesel cranes of 10 to 30 tons, seven mobile rubber-tired cranes of 15 to 50 tons, five diesel shovels of 2½ to 4 cu yd, two 2½ cu yd electric shovels, and 16 diesel bulldozers and excavators rated 8 to 35 tons.

Mill rolls for the entire plant are designed and conditioned in five roll shops, all located in Plant No. 2.

TABLE XIII
Chicago Heights Mill

Stand No.	Roll diameter, in.	Roll body length, in.	Drive motor			Roll, rpm	Roll face, fpm
			HP	Type	Rpm		
1	18	48	350	a-c	514	75	353
2	14	50	250	d-c	300/600	96/192	352/705
3	14	50	400	d-c	450/900	102/204	374/748
4	14	40					
5	14	40	1000	a-c	168/225	168/225	615/825
6	14	40					
7	14	40					
8	14	30					
9	14	30					
10	14	30	1000	a-c	168/225	168/225	615/825
11	14	30					
12	14	30					

The main shop, near the merchant mills, serves the various shape mills. It contains a 36-in. contour lathe, a 48-in. contour lathe, three 18-in. tandem block lathes, four 26-in. tandem block lathes, 13 block lathes covering a size range of 34 to 60 in., a 16-in. roll grinder and a 15-in. milling machine.

Three shops are located in No. 2 cold mill to serve the hot and cold strip mills. One of these contains a 36, a 60 and two 52-in. roll grinders. A second has two 36-in. roll grinders, a 26-in. milling machine and a 60-in. spall cutter. The third shop has three 36-in. roll grinders, four 28-in. roll grinders and two shotblasting units.

Another strip mill roll shop (No. 4) is located in No. 3 cold mill. It contains three 60-in. roll grinders, a 60-in. contour lathe and a shotblast unit.

In addition, there is a 36-in. roll grinder located at the 100-in. plate mill in Plant No. 1 for conditioning the rolls for that mill.

In a typical month the roll department conditions about 1100 shape mill rolls and 8000 strip mill rolls.

Inland was a pioneer in the safety movement and considers safety a primary responsibility throughout its operations. The Harbor works is divided into eight safety areas, each with a staff safety engineer who covers his area to watch for and eliminate hazards and unsafe practices. Some of the larger departments also employ safety inspectors. Among extensive programs conducted by the safety and plant protection department are first aid training, gas protection training and fire fighting techniques. Departmental supervisors also carry on safety education and hold regular safety meetings. Well-equipped hospital and ambulance facilities are available.

The merchant mill at the Chicago Heights plant is at present devoted principally to rerolling steel rails. It is being expanded to handle a greater proportion of billets.

CHICAGO HEIGHTS PLANT

The seed from which Inland sprouted, the original plant at Chicago Heights, Ill., is still a producing unit of the company. As now constituted, the rolling mill is a Belgian cross country combination devoted principally to rerolling steel rails. There are 12 stands as listed in Table XIII. No. 1 stand is the slitter, No. 2 stand is a web rougher, and No. 3 stand is a head and flange rougher. Stands No. 4, 5 and 6 are, respectively, a flange rougher, strander and finisher. No. 7 is a head rougher, No. 8 the head strander and No. 9 the head finisher. No. 10, 11 and 12 are a web rougher, web strander and web finisher, respectively. The mill can also reduce 1¾ to 2⅝-in. square billets.

Steel to be rolled is heated in an end-charged, side-discharge continuous furnace 50 ft long x 18 ft wide. The furnace is heated with gas or oil and has a nominal capacity of 40 tons per hr.

The products include angles from ¾ x ¾ in. to 3 x 2 in., rounds and squares from ½ to 1¼ in., flats from ¾ x ¼ in. to 2¼ x ⅝ in., bands from No. 12 gage x 1 in. to 3/16 x 3 in., and special shapes, fence posts, tees, U-bars, channels and bevel blades. The mill averages about 21 tons per hr, but has produced as much as 310 tons per 8-hr turn.

In process, the steel is descaled by 600-psi sprays located between the heating furnace and the slitter stand.

There are two single cooling beds and a double cooling bed to receive product from the mill.

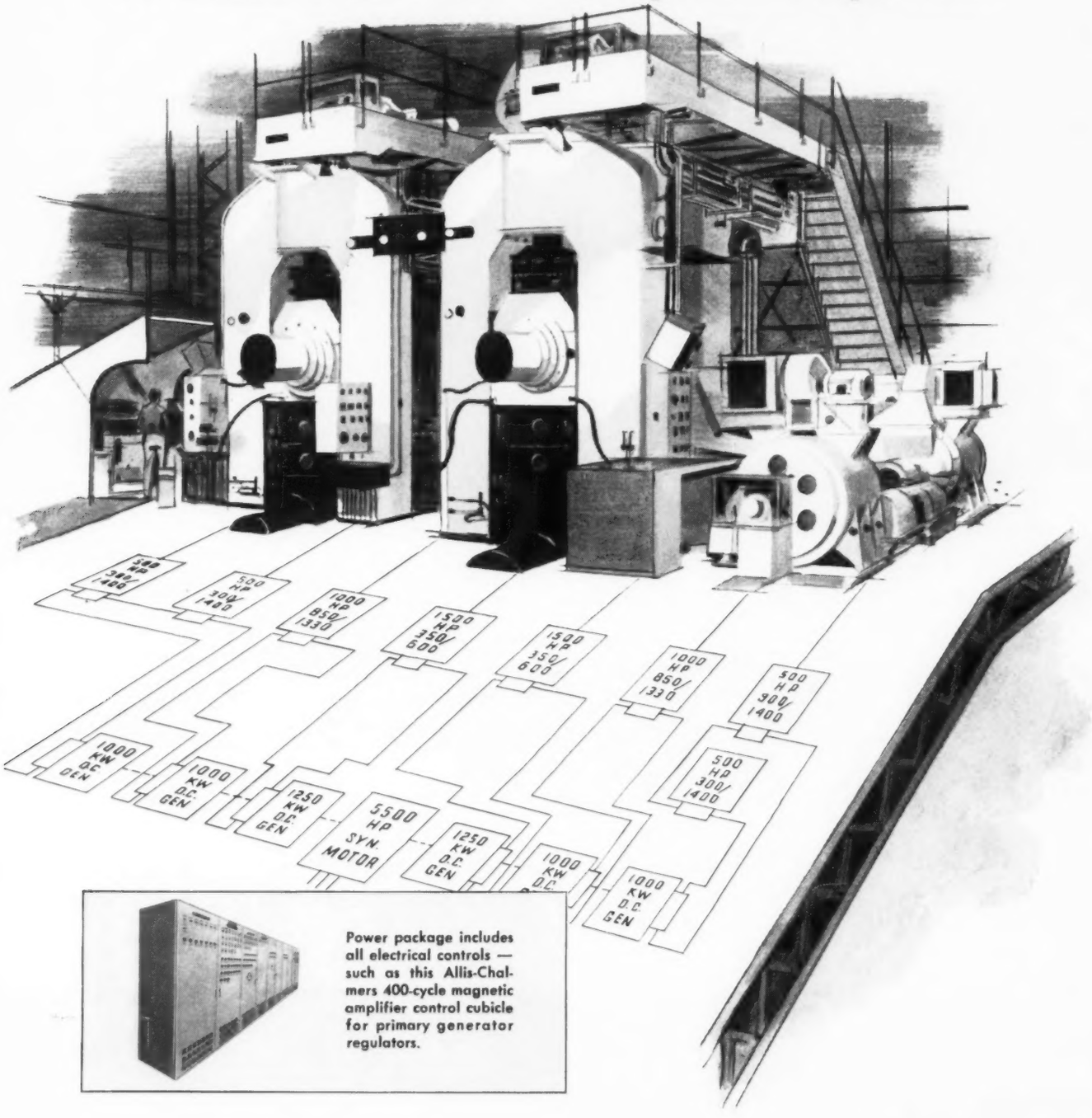
Shears, straightening equipment and a stress-relieving furnace complete the equipment installed in this plant, which has a nominal rating of 90,000 tons per year. An expansion program currently under way here will provide a 50-ton heating furnace, additional roughing stands and improved finishing facilities. By 1960, these improvements will increase capacity to 140,000 tons per year.

* * * * *

The story of Inland Steel is a story of progress under the free, competitive enterprise system. It is also a saga of the Block family. Joseph Block was a moving spirit in founding the company in 1893. He, with P. D. Block and, later, L. E. and E. J. Block, developed a succession of fine steelmaking teams which brought Inland to its present prominence. Their descendants are today active in top management, guiding the company to even greater stature.

Allis-Chalmers power package

for Inland Steel's new 7000-fpm tin temper mill



Power package includes all electrical controls — such as this Allis-Chalmers 400-cycle magnetic amplifier control cubicle for primary generator regulators.

A standout example of planned development by one of America's leading steel producers is this two-stand tin temper mill — soon to be installed at Inland Steel's Indiana Harbor facility.

Allis-Chalmers was selected to engineer and build the complete power package for this advance-design mill — including main-drive motors, supporting motor-generator sets and controls.

The choice of equipment was motivated by prior experience with Allis-Chalmers ability to design optimum efficiency. The fast-acting controls, for example, make possible instant variation of factors affecting strip width and thickness . . . promote consistently high product quality by meeting all requirements specified by Inland Steel and Mesta Machine.

For more information, contact your nearby A-C office or write Allis-Chalmers, Milwaukee 1, Wis.

ALLIS-CHALMERS A-C

A-1182-1S

45" x 90" Universal Slabbing Mill.

22" & 56" x 56" 4 High, Temper Pass Mill.

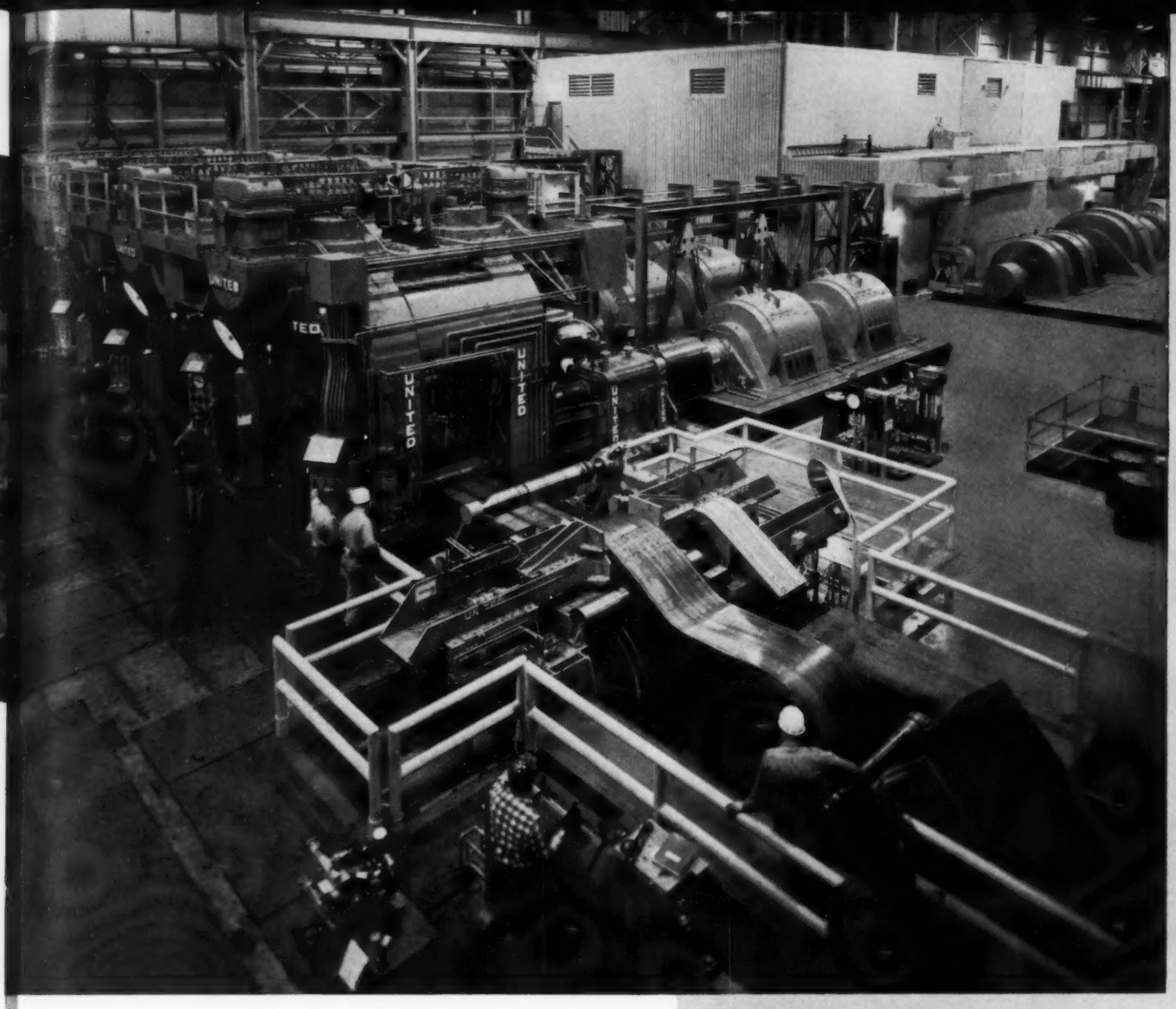
some recent installations of

UNITED

MILLS and EQUIPMENT at INLAND

Slab Pilers and Tables.

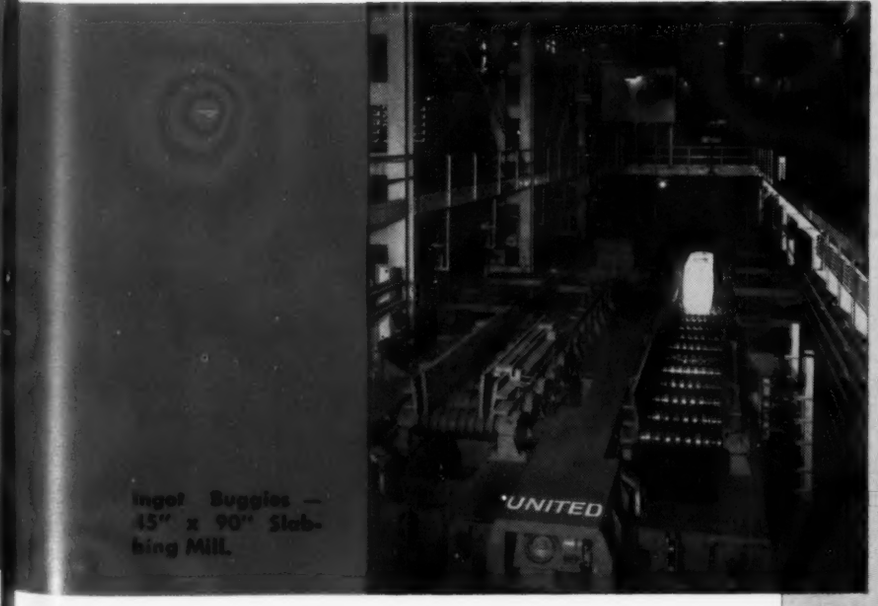
Down and Upcut Shear.



21" & 56" x 56" 4 High,
4 Stand Tandem Cold Mill.

STEEL COMPANY

EAST CHICAGO, INDIANA



Ingot Buggies — 45" x 90" Slabbing Mill.

UNITED

ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at Pittsburgh, Vandergrift, Youngstown, Canton, Wilmington

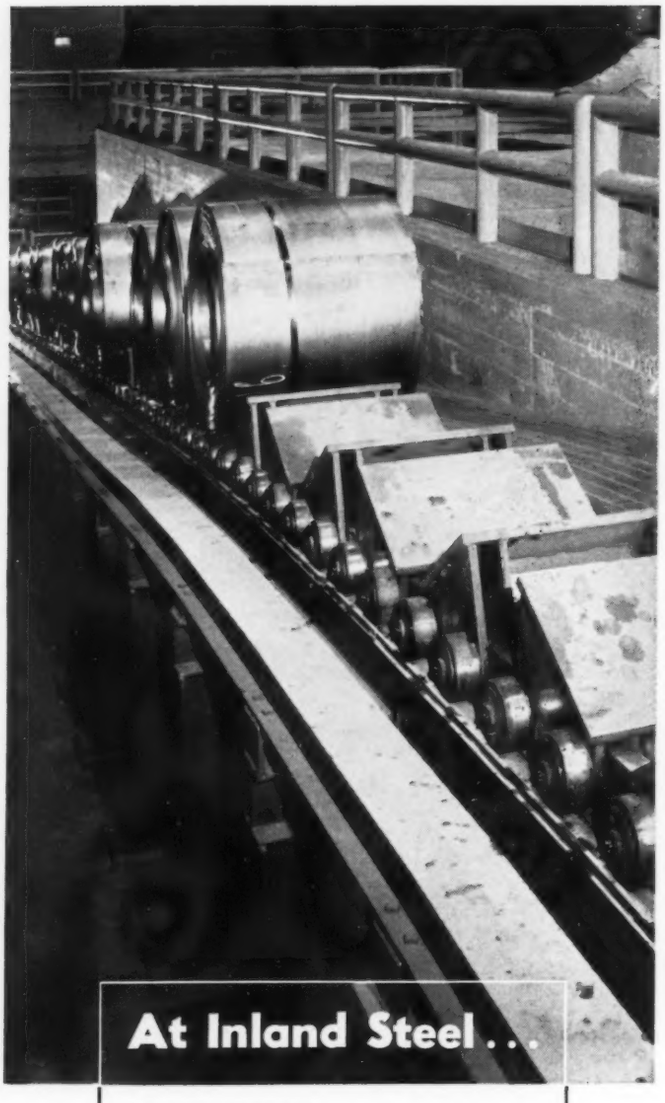
SUBSIDIARIES: Adamson United Company, Akron, Ohio

Stedman Foundry and Machine Co., Inc., Aurora, Indiana

Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery. Manufacturers of Iron, Nodular Iron and Steel Castings and Weldments.

At Acme Steel...

RAW MATERIALS for charging cupola are handled by Link-Belt conveyor system. Car Shaker assists in the unloading of R. R. cars. Belt feeder and inclined belt conveyor carry materials to storage bunkers. Shuttle belt conveyor reclaims materials.



At Inland Steel...

FINISHED PRODUCT — Coils weighing 15-tons each move automatically with precision and safety on Link-Belt conveyor system. From coiler to pickling line, coils are handled without damage. Here coils ride up to storage area on inclined saddle-top roller chain conveyor.

Two mills tell the story: How LINK-BELT equipment

cuts "carrying charges" in steel production

Link-Belt's many types of conveyors are carrying materials through every step of the steel-making process.

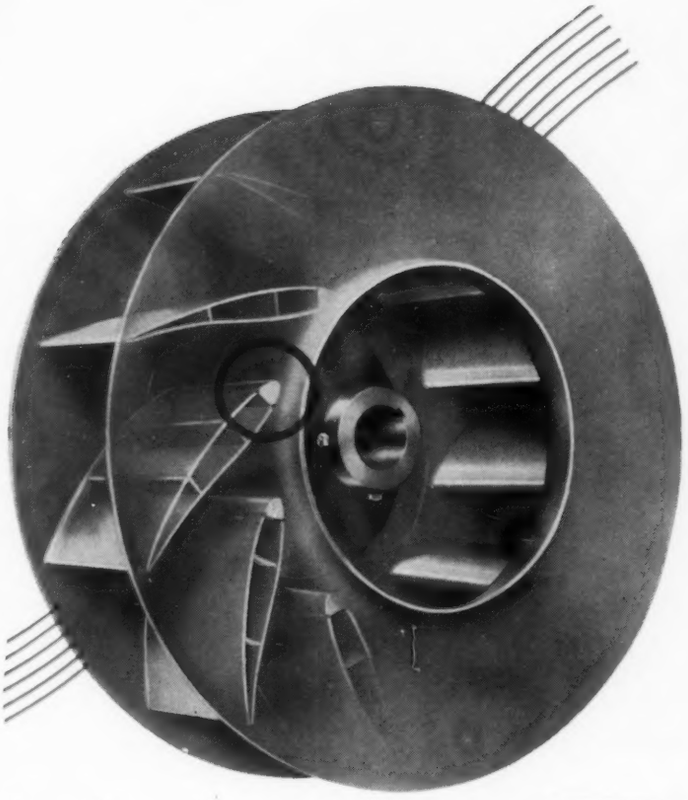
From raw materials to the finished product, Link-Belt's materials handling equipment eliminates many rehandling bottlenecks, cuts costs with efficient handling methods, reduces waste, improves safety and working conditions.

For more information on profitable materials handling all the way through the mill, call or write your nearest Link-Belt office. Our engineers will work with you and your consultants in selecting the right conveyor.

LINK-BELT

One source . . . one responsibility for materials handling, processing and power transmission machinery

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,261



COSTS HELD DOWN WHEN ® INLAND INCLUDED

Green Airfoil Fans

IN FURNACE REBUILDING

At their #2 plant in East Chicago, Indiana, Inland Steel completely rebuilt and enlarged their furnaces to increase production. These rebuilt furnaces called for greater induced draft capacity in the waste heat boilers. The old fan installation of 7 Green radial blade fans had been installed 24 years ago.

Inland Steel replaced these 7 Green fans with 7 Green AIRFOIL induced draft fans. No changes were made in the original motors or electrical system. The 7 Green AIRFOIL fans took care of the increased draft requirements without overload on the original 125 hp motors.

In short, the new Green AIRFOIL fans made it possible for Inland Steel to increase the size and capacity of their furnaces without the expense of new motors and electrical installations in addition.

The Green AIRFOIL design provides smooth airflow with a minimum of turbulence. For longer life, the AIRFOIL fan blades have specially designed cast steel nose pieces to reduce wear. (See circled nose piece in illustration.)

If you have a tough job for heavy duty fans, it makes sense to talk over your problem with Green.

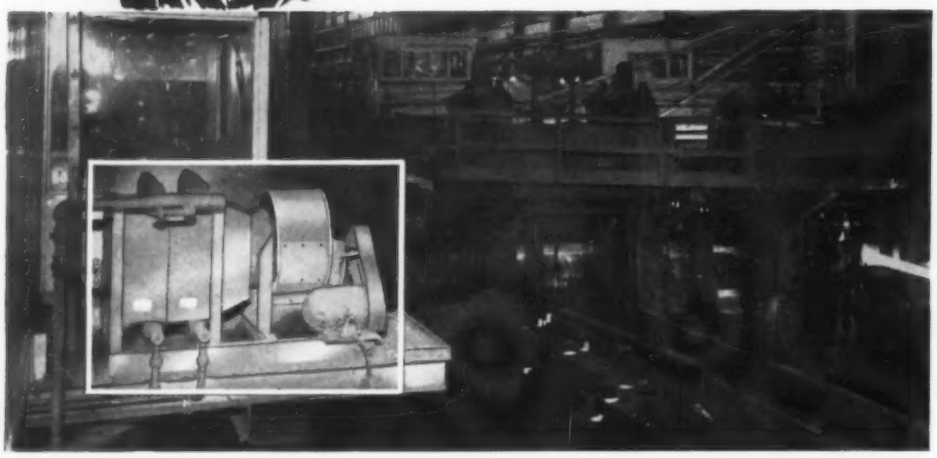
Green

THE GREEN FUEL ECONOMIZER CO., INC.,

BEACON 3, NEW YORK

PROBLEM!

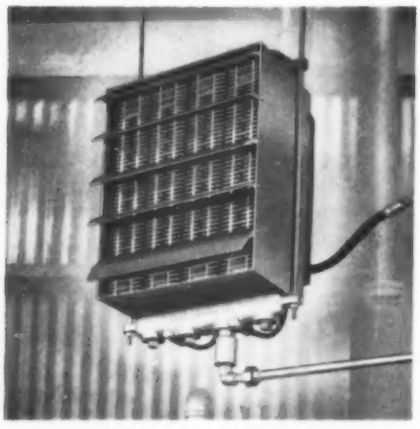
Prevent OIL AND WATER LINE FREEZING AT GROUND LEVEL AROUND ROLL STAND FOOTINGS.



One of Three Grid High Velocity Blower Units installed in Inland Steel's Plant #2-28" Mill Building.

SOLUTION!

GRID HIGH VELOCITY HEATING UNITS consisting of all cast iron Blast Heaters with belt driven, high speed blower. These special units operate on 150 P.S.I. steam pressure at 450 degree Fahr. temperature. Air is raised from 10 to 20 degrees at inlet side to 150 degrees at discharge. Air discharge nozzles located below the platform force heated air in downward, angular direction to ground level. Air velocity 2500 to 2700 F.P.M. Air volume 4100 C.F.M.



One of 62 High Test Cast Iron Grid Unit Heaters installed in Inland Steel's Sintering Plant, East Chicago, Ind.

PROBLEM!

USE STEAM FOR COMFORT HEATING THROUGH UNIT HEATERS IN SINTERING PLANT. STEAM SERVICE 225 P.S.I. PRESSURE REDUCED TO 75 P.S.I., 600 DEGREE TEMPERATURE WITH 300 DEGREE SUPER HEAT.

SOLUTION!

GRID special alloy HIGH TEST cast iron Unit Heaters. Alloy iron heating elements and top and bottom headers designed to withstand 75 P.S.I. steam pressure with 300 degree super heat. All parts subject to pressure are made for maximum of 225 P.S.I., in event reducing valves fail. Motors are equipped with special insulation and heat stabilized bearings. Fans are arranged with heat shields to reflect radiant heat.

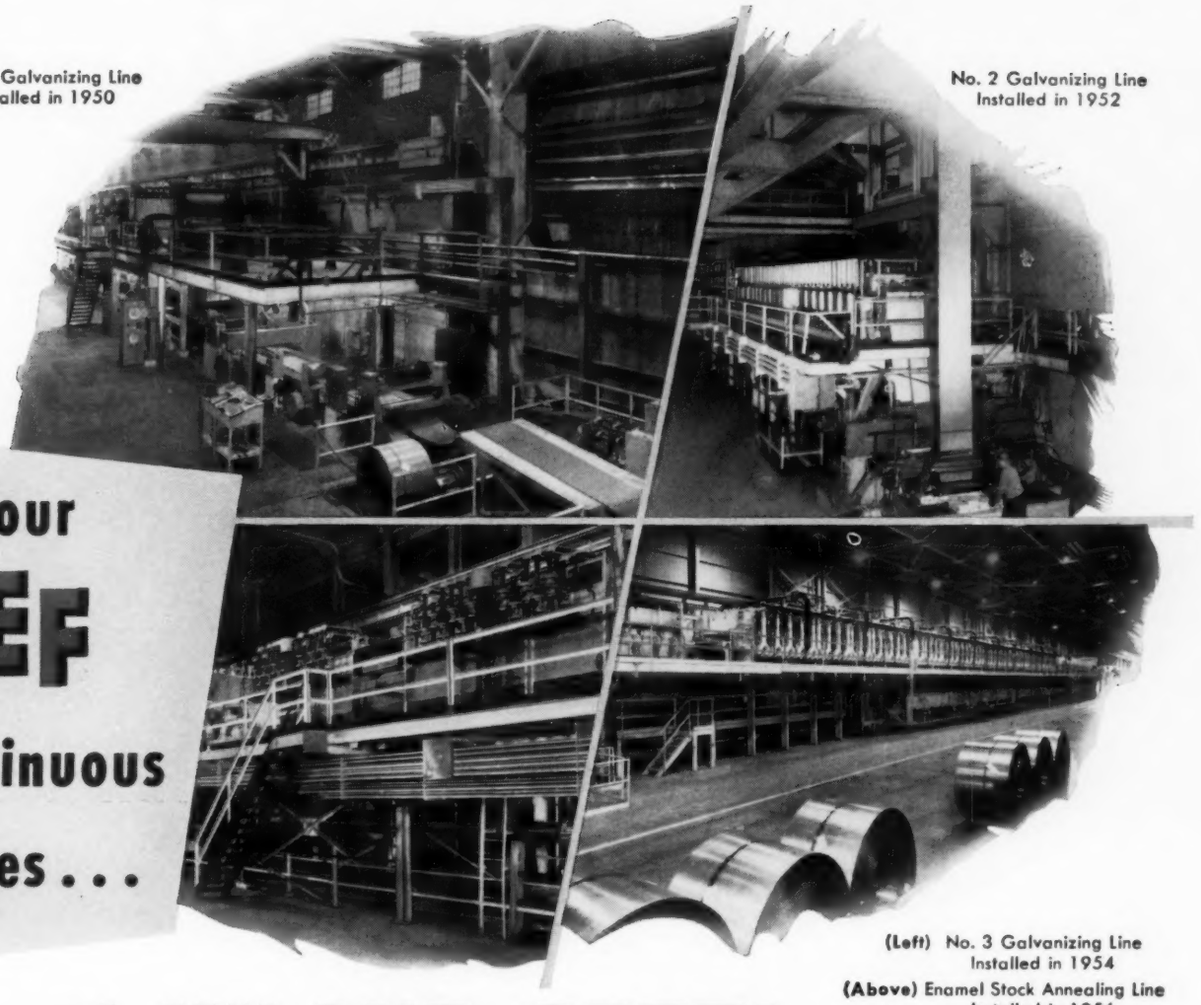
FOR MAINTENANCE FREE HEATING SERVICE AND FOR THAT DIFFICULT STEEL MILL HEATING PROBLEM, SPECIFY GRID CAST IRON UNIT HEATERS, BLAST HEATERS AND RADIATORS.

Engineering consultation service without obligation. Write for catalog 956, the complete Grid Story.

Manufacturers Since 1883 **GRID**

D. J. MURRAY MANUFACTURING CO.

WAUSAU, WISCONSIN



No. 1 Galvanizing Line
Installed in 1950

No. 2 Galvanizing Line
Installed in 1952

Four EF Continuous Lines . . . at INLAND STEEL

(Left) No. 3 Galvanizing Line
Installed in 1954

(Above) Enamel Stock Annealing Line
Installed in 1956

provide efficient 24 hours a day, 7 days a week operation at high efficiency, with no unscheduled downtime.

TOTAL DESIGN CAPACITY IN EXCESS OF 617,000 TONS PER YEAR*

Repeat orders are the highest endorsement a furnace builder can earn. Tailored to meet Inland's specific requirements, and incorporating the most advanced technological improvements, these four EF continuous lines assure accurately controlled cycling, maximum production and maximum return per dollar invested.

The unvarying day after day uniformity of product physicals, assure highest market acceptance, and make subsequent forming and fabricating operations more efficient and less costly.

For up to the minute engineering, outstanding performance, and greatest return on your investment, on any continuous — or batch — ferrous or non-ferrous heat treating project, you'll find, like Inland, that "it pays to call the EF furnace engineers".

*Tonnage output will vary depending upon width and gauge of strip being processed.

EF

THE ELECTRIC FURNACE CO.

Gas-fired, Oil-fired and Electric Furnaces for Heat Treating any Product, Using any Process, any Hourly Output.

300 West Wilson Street *Salem - Ohio*

Branch Offices in Detroit, Mich., Santa Ana, Calif., and Cheshire, Conn. Canadian Associates, Canefco Limited, Toronto 13, Ontario

ATLAS

...serving

Inland Steel's

Indiana Harbor

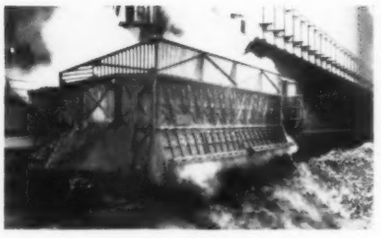
Works

since 1907

60-Ton Double-Hopper Side Dump Ore Transfer

15-Ton Scale Car
at Stock House Bins

Battery Operated
Roll Transfer Car

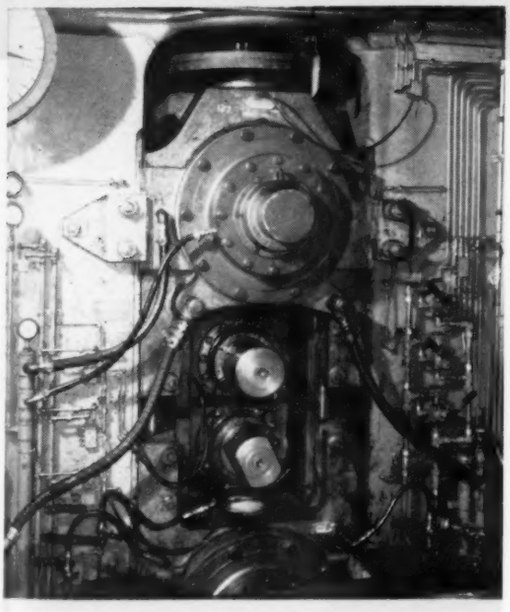


Coke Quencher
unloads at wharf

ATLAS CAR & MFG. CO.
1140 IVANHOE RD. • CLEVELAND 10, OHIO

MORGOIL
BEARINGS

Above: 21" x 56" x 56" 4-High, 4-Stand Tandem Cold Strip Mill
Below: 22½" x 56" x 56" 4-High, Single Stand Temper Pass Mill



MORGAN WORCESTER

Meet the DEMAND of TOP QUALITY PRODUCTION

The demonstrated ability to meet high speeds, heavy loads and close tolerances made MORGOILS a natural choice for the back-up rolls on Inland Steel's new Cold Mills at the Indiana Harbor works.

Both the new 4-High, 4-Stand Tandem Cold Strip Mill and the new 4-High Single Stand Temper Pass Mill are equipped with 44"-90 MORGOIL BEARINGS.

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS
ROLLING MILLS • MORGOIL BEARINGS • WIRE MILLS
GAS PRODUCERS • EJECTORS • REGENERATIVE FURNACE CONTROL

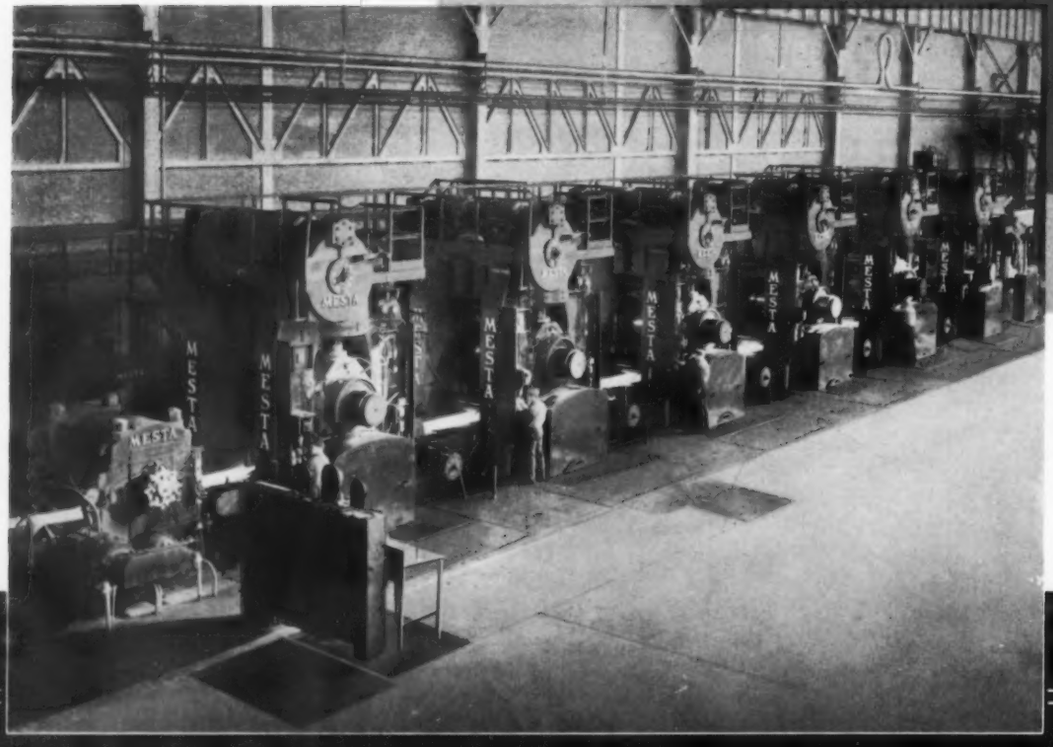
MB 33

MESTA 46" TWO-HIGH REVERSING SLABBING-BLOOMING MILL WITH MANIPULATORS AND TABLES

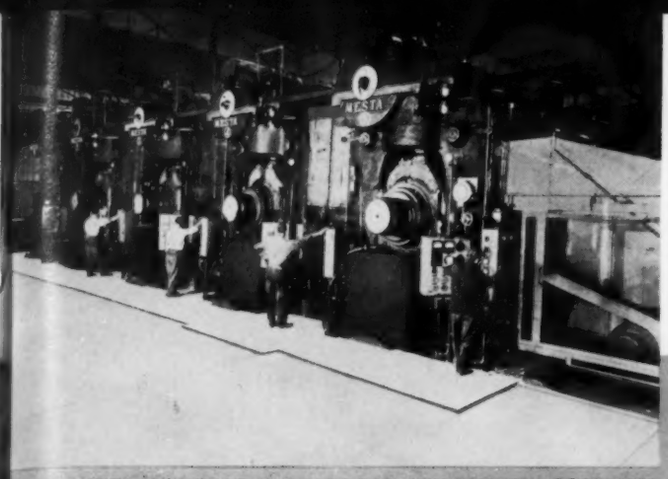
MESTA 76" FOUR-HIGH CONTINUOUS HOT STRIP MILL

Designed and Built by MESTA

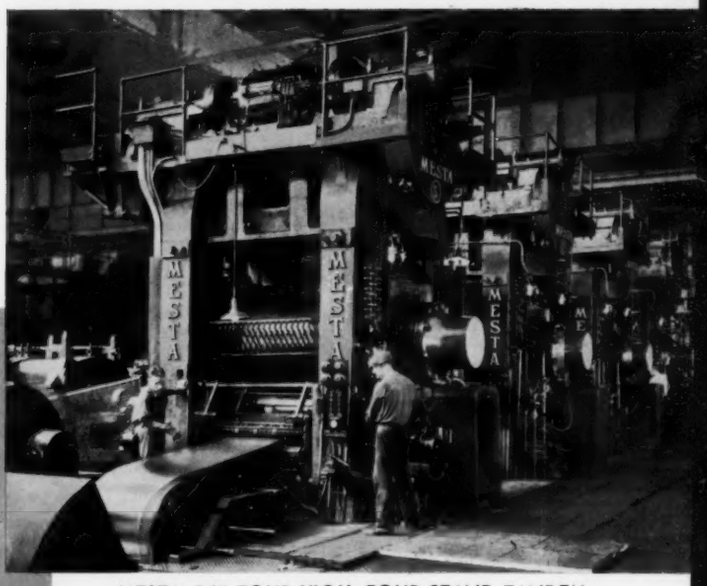
FOR . . . .



MESTA 44" FOUR-HIGH CONTINUOUS HOT STRIP MILL—FINISHING STANDS

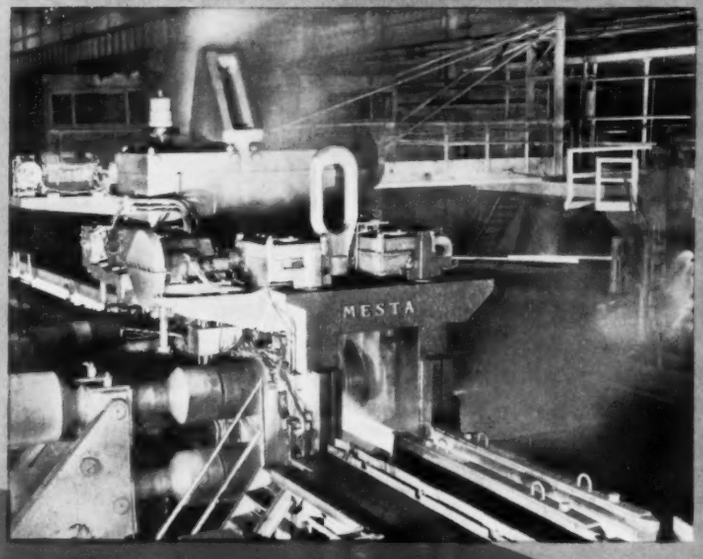


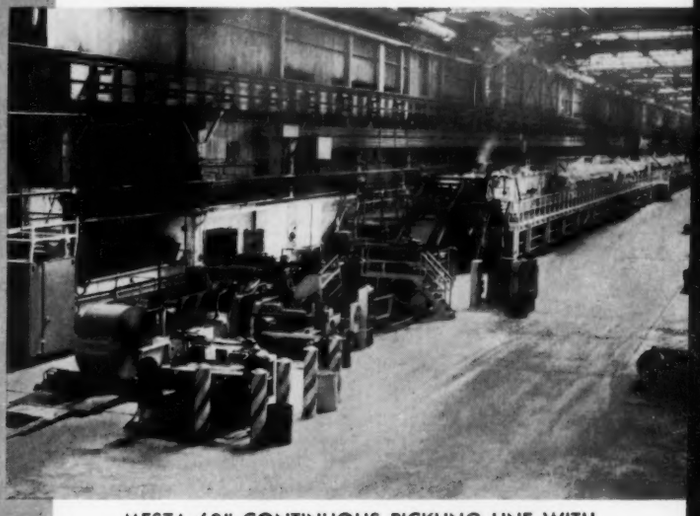
MESTA 42" FOUR-HIGH, FIVE-STAND TANDEM COLD MILL



MESTA 54" FOUR-HIGH, FOUR-STAND TANDEM COLD MILL

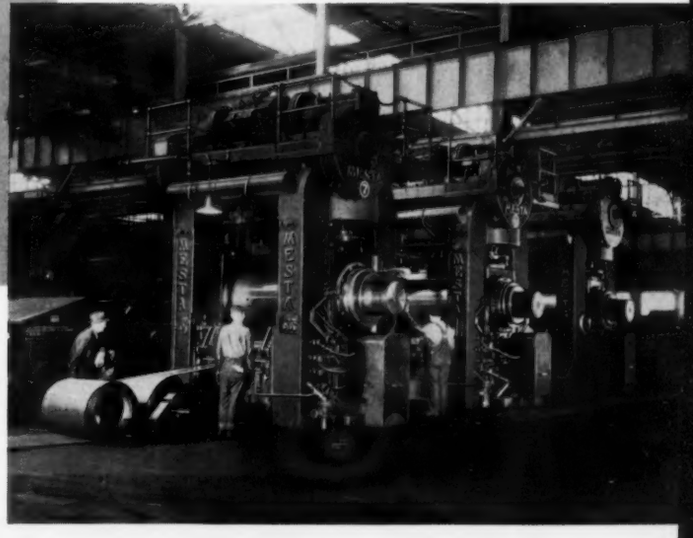
MESTA UNIVERSAL STRUCTURAL MILL ROLLING WIDE FLANGE BEAMS ON THE 44" UNIVERSAL STAND AND THE 34" EDGING STAND





MESTA 60" CONTINUOUS PICKLING LINE WITH FLASH WELDER, TRIMMER AND UP-COILER

. . INLAND
STEEL COMPANY



MESTA 72" FOUR-HIGH, THREE-STAND TANDEM COLD MILL

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

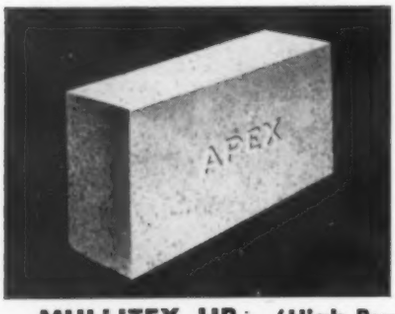
PITTSBURGH, PENNSYLVANIA

MESTA
THERE IS NONE BETTER

Performance Proved
...IN THE STEEL INDUSTRY

WARCO XXD—Checker Brick (DP)

With its lower porosity and higher bulk density, Warco XXD High Duty Fire Brick is famous for unusual resistance to thermal shock. Especially recommended for checker brick work in open hearths, hot blast stoves and for use in soaking pit coping tile, Warco XXD is the last word in physical properties that assure greater value per dollar invested.



APEX—Super Duty Fire Clay Brick

Weigh in excess of 150 lbs. per cu. ft. For maximum resistance to abrasion, slag penetration and metal wash. Assure record tonnages for your hot metal torpedo type ladles, hot metal mixers and for top checkering open hearths and hot blast stoves.

MULLITEX HB—(High Burn) Super Duty Fire Brick

Noted for high hot load bearing strength and good resistance to thermal shock, producing volume stability at molten steel temperatures under continuous hot metal load.

MULLITEX—Super Duty Fire Brick

Noted for its slag resistance and ability to withstand heat and sudden temperature variations without shrinking or spalling.

MORT-AIRSET—High Temperature Airsetting Cement

A versatile bonding mortar combining excellent working, drying and non-shrinking properties. Produces remarkably tight joints throughout the complete temperature range and is **GUARANTEED** not to "gum up" or lump in the drum. A favorite in steel mills where strong, gas tight joints are required. In 500 lb. and 200 lb. steel drums and smaller steel containers.

BB 161 SUPER PLASTIC

Cold setting high strength super duty plastic fire brick. Particularly suited for soaking pit curbs. PCE 33-34. In 100 lb. "E Z" zip open cartons—sliced, ready for use.

CAST COVER MIX—Refractory Castable

Especially designed for soaking pit cover linings and other steel mill applications. Air gunned or cast into place. Time and labor saving. In 100 lb. moisture-proof bags.

METALOK—Heat Setting Mortar

For retarding joint penetration in iron and steel melting operations. Unusual resistance to heavily-laden iron oxide slags in iron and steel ladles. In 100 lb. bags.

WALSH LADLE BRICK (DP)

Withstand the progressively higher temperature requirements of open hearth and electric furnace heats at tap time as well as the greater mechanical and temperature shock brought about by the sudden velocity of metal pouring occurring in modern jet tapping. Available in straights and series shapes and many special shapes.

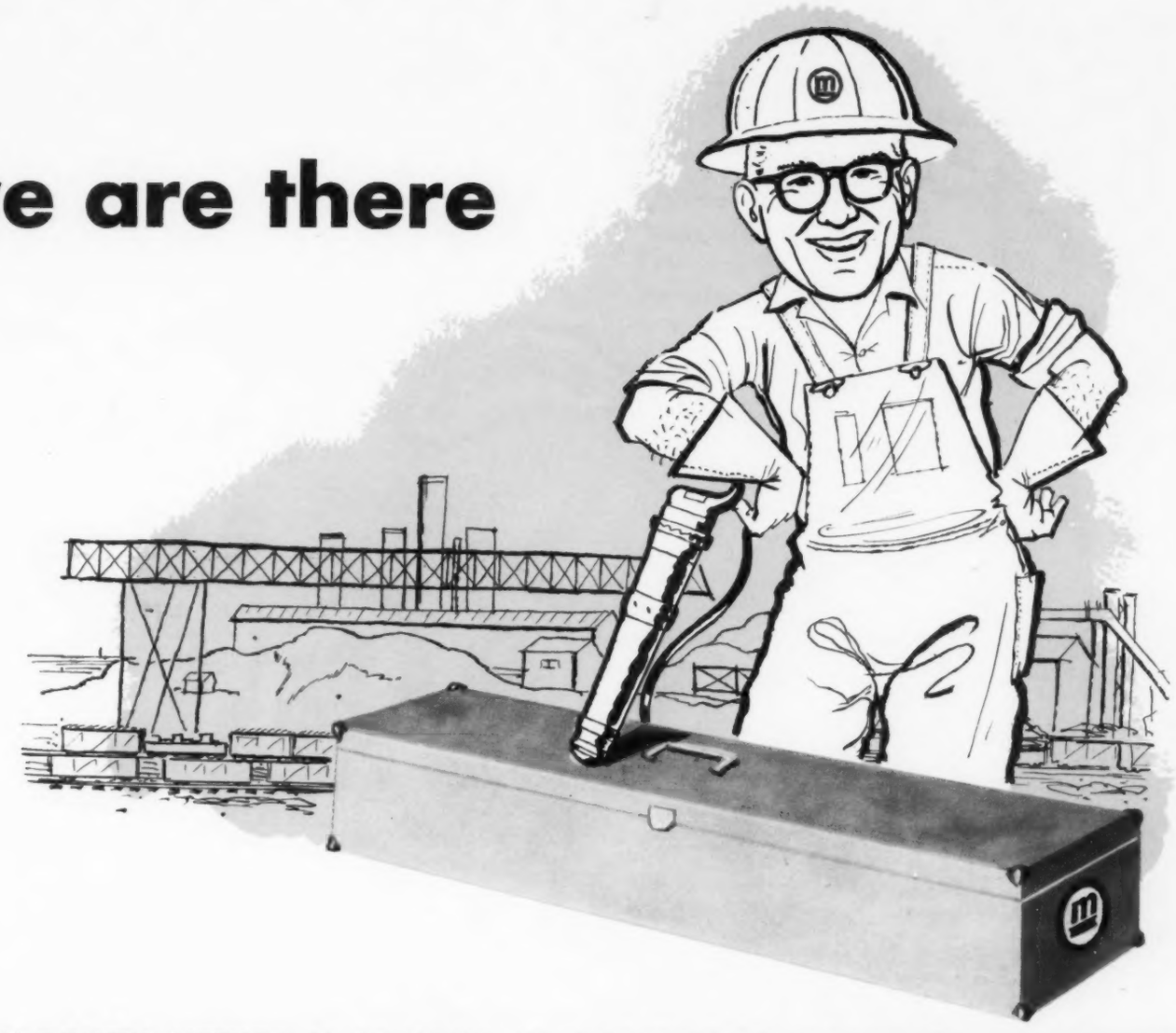
For complete information on Performance-proved Walsh Refractories, wire, write or phone:

WALSH REFRACTORIES CORPORATION

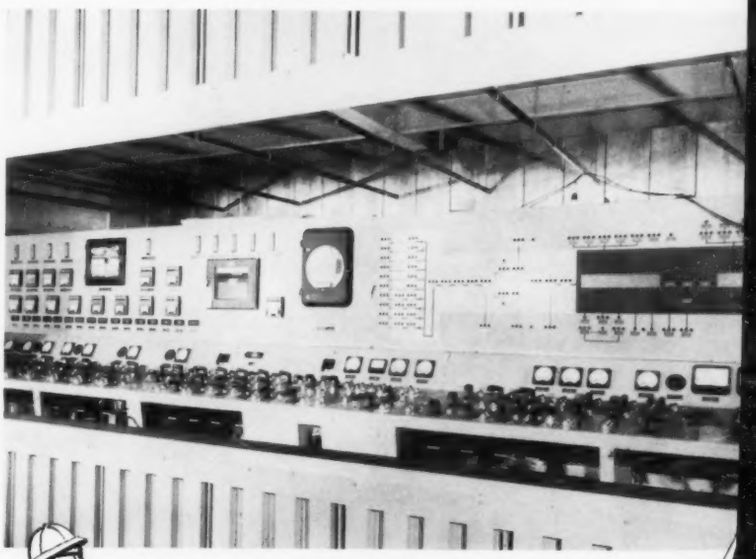
101 FERRY STREET • ST. LOUIS 7, MISSOURI

SPECIALISTS IN REFRACTORIES OF HIGH BULK DENSITY AND LOW POROSITY

we are there

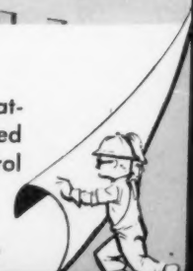


THE McDOWELL METHOD IS AT HOME AT **INLAND'S HARBOR WORKS**

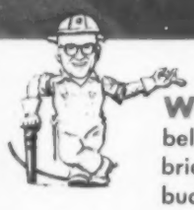


WE ARE THERE in the 5000 ton per day Dwight-Lloyd® ferrous sintering plant engineered and installed turnkey on made land.

WE ARE THERE in automated sintering, shown by this advanced Dwight-Lloyd® one-man master control center (under construction).

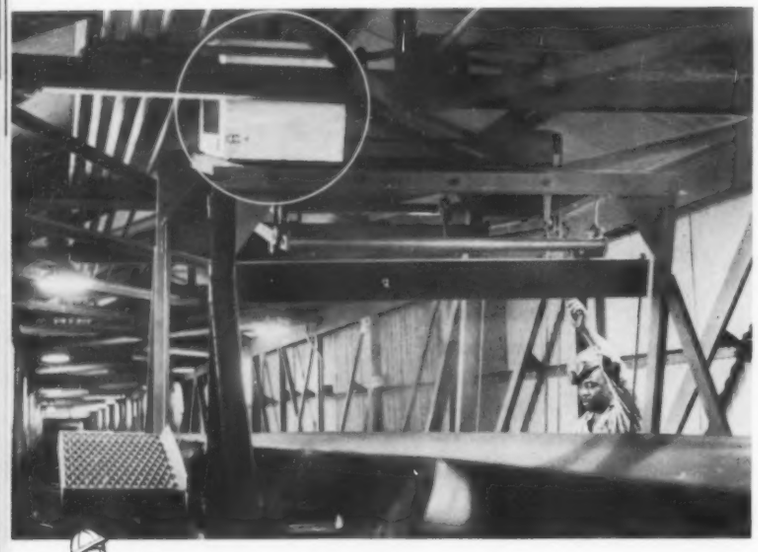


and

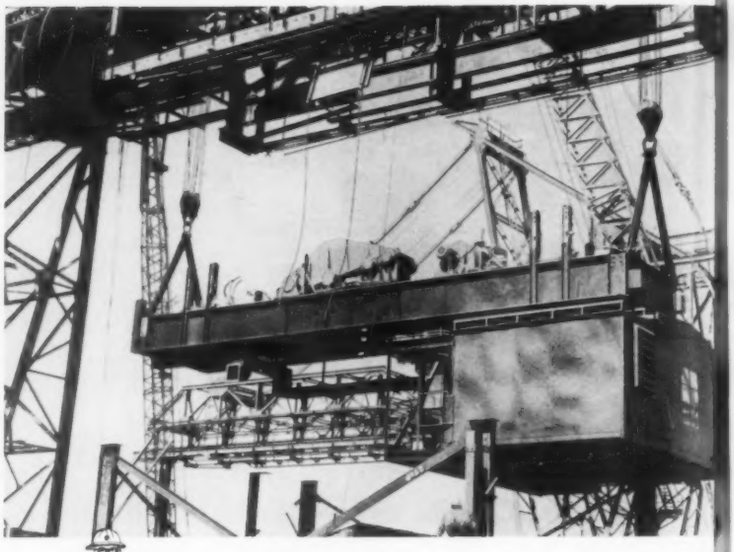


WE ARE THERE in the three Wellman belt conveyor stocking and reclaiming coal bridges equipped with our 6¾ ton Williams buckets.

WE ARE THERE in the two 20 gross ton Wellman ore bridges and the many Williams engineered buckets, Wellman-exclusive.



WE ARE THERE in the 16 McDowell ABCs® belt conveyor scales and feeders which automatically proportion and weigh the sinter mix and total burden.



WE ARE THERE in the modernization of two ore bridges to include light-weight 20 gross ton capacity Wellman trolleys.

THE McDOWELL WELLMAN COMPANIES

McDowell Turnkey Plants • Dwight-Lloyd Research Laboratories

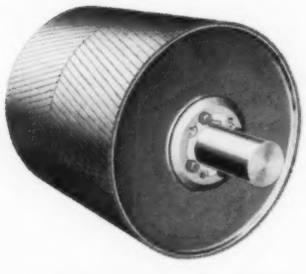
Wellman Bulk Materials Handling Systems and Steelmaking Machinery

Anker-Holth Power Cylinders • Wellman-Galusha Gas Producers • ABCs ®Belt Conveyor Scales

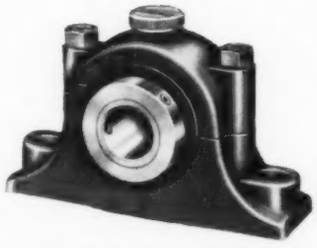
Williams Buckets • Wellman Locomotive Cranes • Dwight-Lloyd ®Ore Beneficiating Plants

Photo courtesy of McDowell Co., Inc.

Dodge dependability built into new sinter plant conveyor system at Inland Steel



DODGE TAPER-LOCK STEEL CONVEYOR PULLEYS



DODGE DOUBLE INTERLOCK PILLOW BLOCKS WITH TIMKEN BEARINGS

Dodge Taper-Lock Steel Conveyor Pulleys and Dodge Double Interlock Pillow Blocks with Timken Tapered Roller Bearings contribute their dependability to this new sinter plant. They are an important part of the extensive conveyor system engineered by Dwight-Lloyd Division of McDowell Company, Inc., Cleveland.

Maximum strength with minimum weight is provided by these rugged conveyor pulleys. Their steel rims, discs and hubs are fused together into jointless drum construction for terrific impact resistance. With the unsurpassed holding power of Taper-Lock mounting there is no "walking on the shaft."

Dodge Double Interlock Pillow Blocks (with Timken Tapered Roller Bearings) were chosen for this hard service. They are rugged, compact, fully self-aligning—with substantial radial and thrust capacities. The extra long inner race distributes load over a greater shaft area. They are adjusted, lubricated and sealed at the factory—for a long life of dependable service.

DODGE MANUFACTURING CORPORATION, 5900 Union St., Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the white pages of your telephone directory for "Dodge Transmissioneer."

TSP gears, track wheels, sheaves on ore bridges.

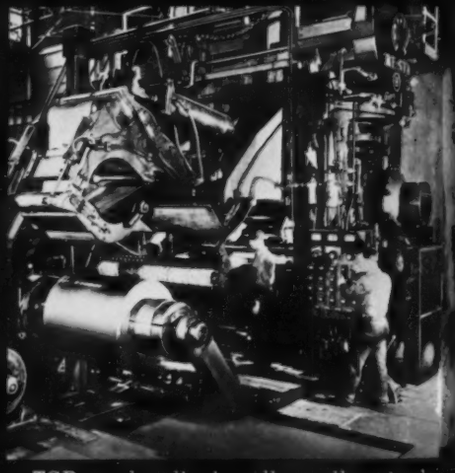
TSP gears, track and brake wheels, sheaves, axles, shafts, racks, on soaking pit cranes.

TSP gears, pinions, wheels on pushers and larry cars.

TSP

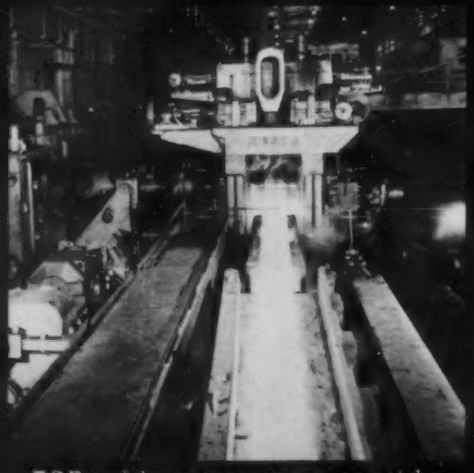
TSP gears, track and brake wheels, sheaves, axles, shafts, on open hearth hot metal cranes.

TSP screwdown screws, table gears, liner plates, manipulator gears and slides, on 46" blooming mill.



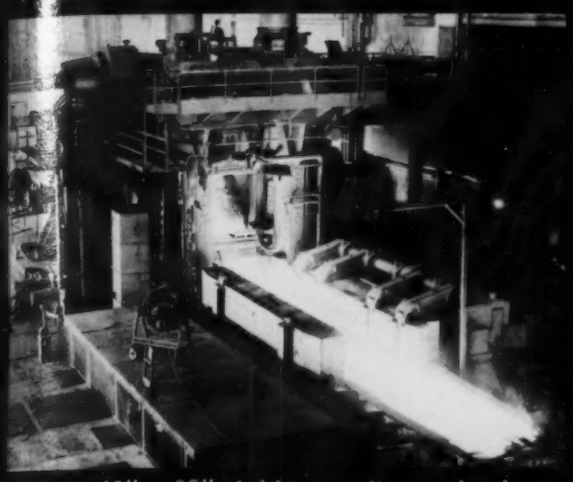
TSP work rolls, leveller rolls, pinch rolls, gears, pinions, racks, on cold strip mill equipment.

TSP sheaves, wheels, mud-gun screws and nuts on blast furnace equipment.

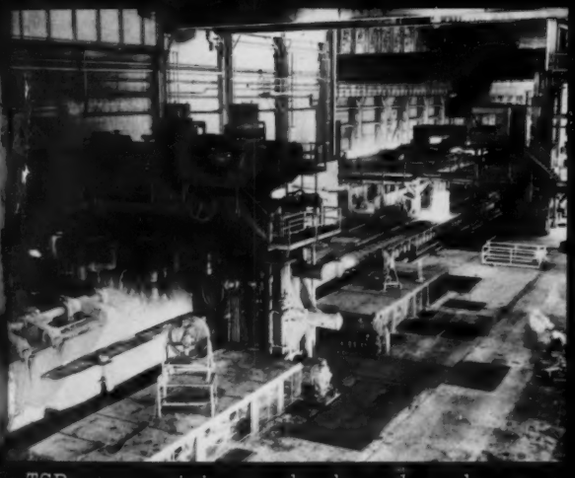


TSP table gears on new wide flange beam mill.

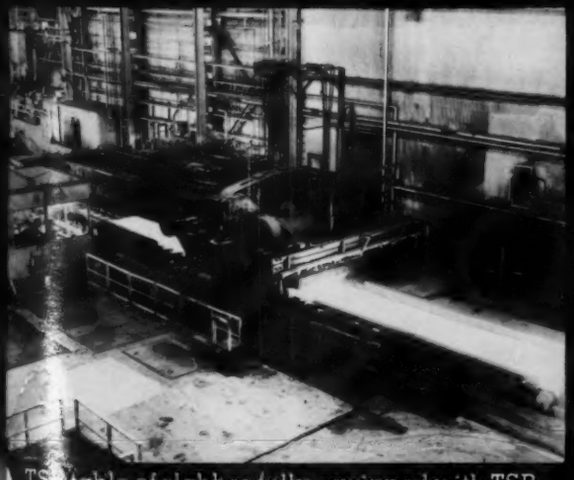
TSP table, gears, crane gears and pinions, shafts, axles, brake and track wheels, on continuous hot strip mill equipment.



New 46" x 90" slabbing mill completely equipped with TSP gearing, screwdown screws, edging roll screws.



TSP gears, pinions, wheels, axles, sheave wheels, and brake wheels on new slabbing mill tables and soaking pit crane in background.



TSP table of slabber fully equipped with TSP bevels and table drive gearing. TSP line shaft and drive gearing on front and back delivery tables in new No. 4 slabbing mill.

That's because "Tool Steel Process" hardened parts are designed and made to maintain continuous productivity of equipment. They last longer, wear better and they cost less in the long run. If they do not deliver per our written guarantee—you get your money back. Inland Steel has bought thousands of TSP parts since 1911. They use TSP gears, pinions, rolls, shafts, wheels, sheaves, axles and many other parts as replacements.

INLAND

Like so many steel mills, they've found that TSP hardened parts pay for themselves, many times over, because of their phenomenally long wearing qualities. A special hardening process used in making TSP parts develops a file hard surface to the full depth of permissible wear. A core, refined for toughness and ductility, gives maximum strength. Write today for complete information on TSP hardened products for the Steel Industry.

TOOL STEEL

CINCINNATI 16, OHIO, U.S.A.

The Standard of Quality Since 1909 for Gears, Pinions, Rolls, Wheels and Other Hardened Products.

MEMBER OF AGMA

AD 1041—Printed in U.S.A.

This Man Can Mean Extra Profit For You

This is a Dowell Service Engineer. He is an expert in the use of chemical solvents to remove scale and sludge from your process systems, boilers, tanks and piping.

Using the exclusive Dowell methods of chemical cleaning, this engineer can free up the profits that these deposits cut from your operating ledger.

More than 15 years experience in all industries—for example, oil refining, chemical, steel, public utilities and paper—give Dowell engineers full knowledge of the problems of cleaning plant equipment.

Add to this experience the benefits you get in special equipment, chemicals, research and trained people.

Put this ability and experience to work for you. Let the Dowell man engineer a profitable chemical cleaning program for you. Dowell—the largest, the oldest, the most experienced chemical cleaning service—Tulsa 1, Oklahoma; and 165 stations and offices in major industrial centers.

Chemical cleaning service for all industry

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

Continuous Electrolytic Cleaning Line, Indiana Harbor Works, Inland Steel Company

Wean, Inland and Cleaning . . .

Operating at speeds up to 2500 fpm, this Wean tension-type, electrolytic cleaning line has replaced two older washer lines at the Indiana Harbor Works of Inland Steel. It employs grid-to-grid application of electrolytic current to the strip for efficient removal of oil and residue resulting from cold reduction. The line handles coils 18″ to 42″ in width and weighing up to 40,000 pounds.

Of all electrolytic cleaning lines in use today, 80% have been built by Wean, leader in the design and construction of all types of coil processing lines. If you are planning to expand or modernize your sheet, strip, or tin plate finishing facilities, Wean's *creative engineering* can mean important savings to you.

THE WEAN ENGINEERING COMPANY, INC. · WARREN · OHIO

Photo by courtesy of the furnace builders, SALEM-BROSIUS, INC.

9 New Soaking Pit Covers at INLAND!

WITH SUSPENDED RAMTITE® DOMED COVER CONSTRUCTION

The Inland Steel Company is in the limelight in this special edition of "Iron & Steel Engineer." And reflected in the light of the intense heat is RAMTITE, also playing a part in this new featured production.

In the covers of nine new soaking pits in No. 4 Slab Mill at Inland's plant is RAMTITE No. 25, the plastic refractory that has proved so satisfactory for so many uses in so many steel mills.

These pit covers are of the suspended RAMTITE Domed Cover design. Inside those humps is RAMTITE No. 25, now a solid monolithic structure to contain and withstand the heat and harsh jars of constant cover removal. RAMTITE No. 25 is not new to soaking pit covers — nor new to Inland Steel. RAMTITE products are also serving in other capacities in this mill. (*"The best sign of satisfaction is a repeat order."*)

RAMTITE plastic and castable refractories and specially designed anchors can play a leading part in your own production and maintenance. There's a RAMTITE product for virtually every refractory need. Our own supervision is available and always with the fullest co-operation with your Engineering, Mason and Ceramic Departments.

Your local or nearby RAMTITE representative is trained to discuss your problems. Call, phone or write — or use the handy coupon.

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.
1813 South Rockwell St., Chicago 8, Ill.

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 S. Rockwell St., Chicago 8, Ill.

☐ We are interested in Ramtite. Please furnish information.
☐ Send folder about your new Ramtite — "90-RAM"

Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

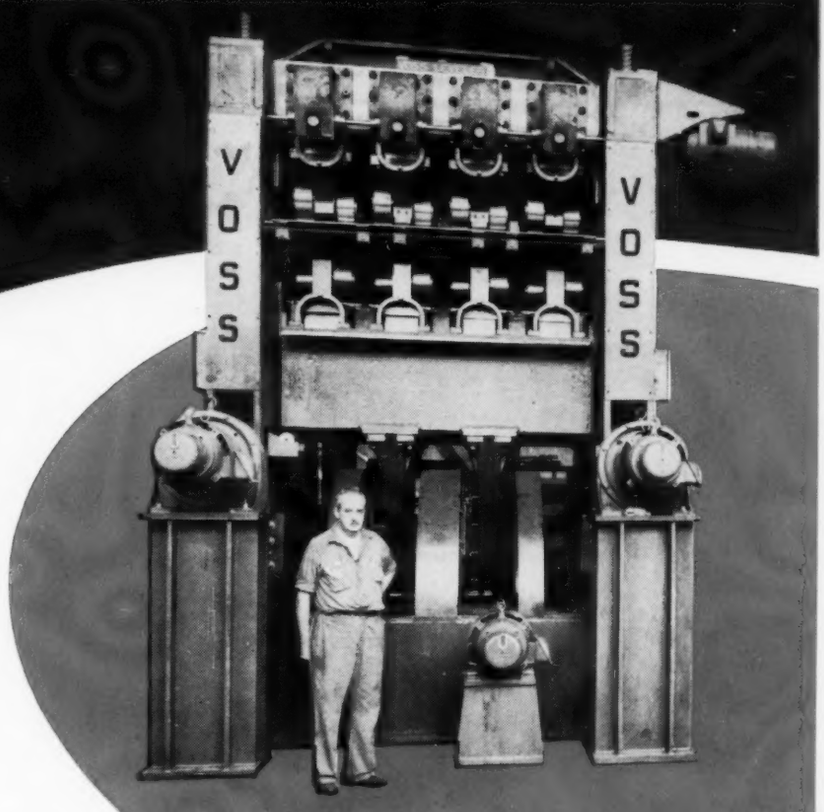


Photo (taken before installation) shows plate leveler now operating at Inland Steel's Indiana Harbor Works.

INLAND STEEL
levels plate with this
VOSS LEVELER...
up to 2000 tons per shift...
speeds to 282 FPM

And it really comes out flat! Talk about versatility: This leveler is designed for hot-rolled plate up to 74" wide, and has a guaranteed thickness range of 3/16" to 5/8". BUT... *Inland Steel is successfully flattening as low as 1/16" floor plate with it.* This particular installation is on a long plate processing line, where shearing is done after leveling. Therefore, the Voss Leveler has been handling plate *up to 40 feet in length.*

Voss Levelers will solve almost any leveling problem *... at high production speeds.* Patented features make possible accuracy and flatness unheard of with any other leveler, *equalling or exceeding stretcher-level flatness* in many cases. Voss Levelers are now in use in steel, aluminum and other non-ferrous plants, in applications ranging from heavy plate to cold-rolled strip, galvanizing lines, aluminum sheets and many others. Let Voss put its years of experience to work for you. Call or Write today.

Voss ENGINEERING CO.

7301 Penn Ave., Pittsburgh 8, Pa. Churchill 2-4422

FOR QUALITY... PRODUCTIVITY ... PROFIT

METAL ROLLING AUTOMATED BY GENERAL ELECTRIC

A NEW CONTROL FOR REVERSING HOT MILLS

G-E program-control system operates

General Electric's new program control for reversing hot mills performs an entire rolling cycle—automatically. Increased yield per ingot, substantially improved product quality and reduced unit cost are outstanding advantages of this new control system.

HOW G-E PROGRAM CONTROL OPERATES

The entire rolling operation, from ingot entry to finished slab, is controlled automatically. A punched card or other memory device is used for data storage and to control the entire operating sequence.

The cards are punched to perform mill functions previously determined to be the most efficient for the equipment involved and the product desired. This controlling element is read by an industrial card reader, which sends impulses to the control circuit and on to the screwdown motors, mill table drives, and manipulator drives. The operator, seated in the pulpit, inserts the card into the reader, depresses a pushbutton, and then the control directs the entire operating sequence. The speed of the mill table, position of the rolls, manipulation of the piece, and sequencing operations for all passes are controlled automatically by the program control system.

Yield is increased—The General Electric program control schedules the mill tables to run at the most desirable and efficient speed. It also brings the rolls into the position calculated for maximum ingot reduction on each pass and turns the ingot at the exact time determined to produce highest slab quality. This precision control produces more finished slabs per turn than manually controlled mills.

entire rolling cycle — automatically

Quality is improved—Greater slab uniformity is obtained with G-E automatic program control. Consistent roll settings and mill speeds produce uniform slabs. This improved quality control also results in substantially less scrap.

Unit cost is reduced—Automatic programming produces finished slabs faster than ever before possible. Higher operating efficiency of machinery and faster equipment adjustment by automatic control cut production time—therein reducing unit cost.

Get all the facts on this new automatic control for steel mills. Contact your G-E Apparatus Sales Engineer today, or write to Sect. 785–10, General Electric Company, Schenectady 5, N. Y., for bulletin GEA-6869. Industry Control Department, Roanoke, Va.

Progress Is Our Most Important Product

GENERAL ELECTRIC

With the accent
on precision . . .

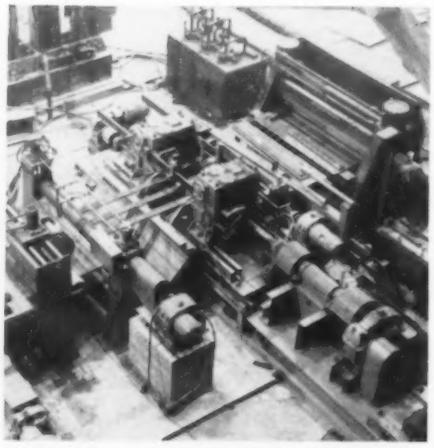
HUNTER CONSTRUCTION COMPANY is a leading installer of facilities for the steel and aluminum industries. Many prominent metal producers have engaged Hunter for the installatian of rolling mills, processing lines, furnaces, and the erection of mill buildings. The major share of our business comes from customers whom we have served numerous times.

One Contract
One Contractor
One Responsibility

HUNTER CONSTRUCTION COMPANY

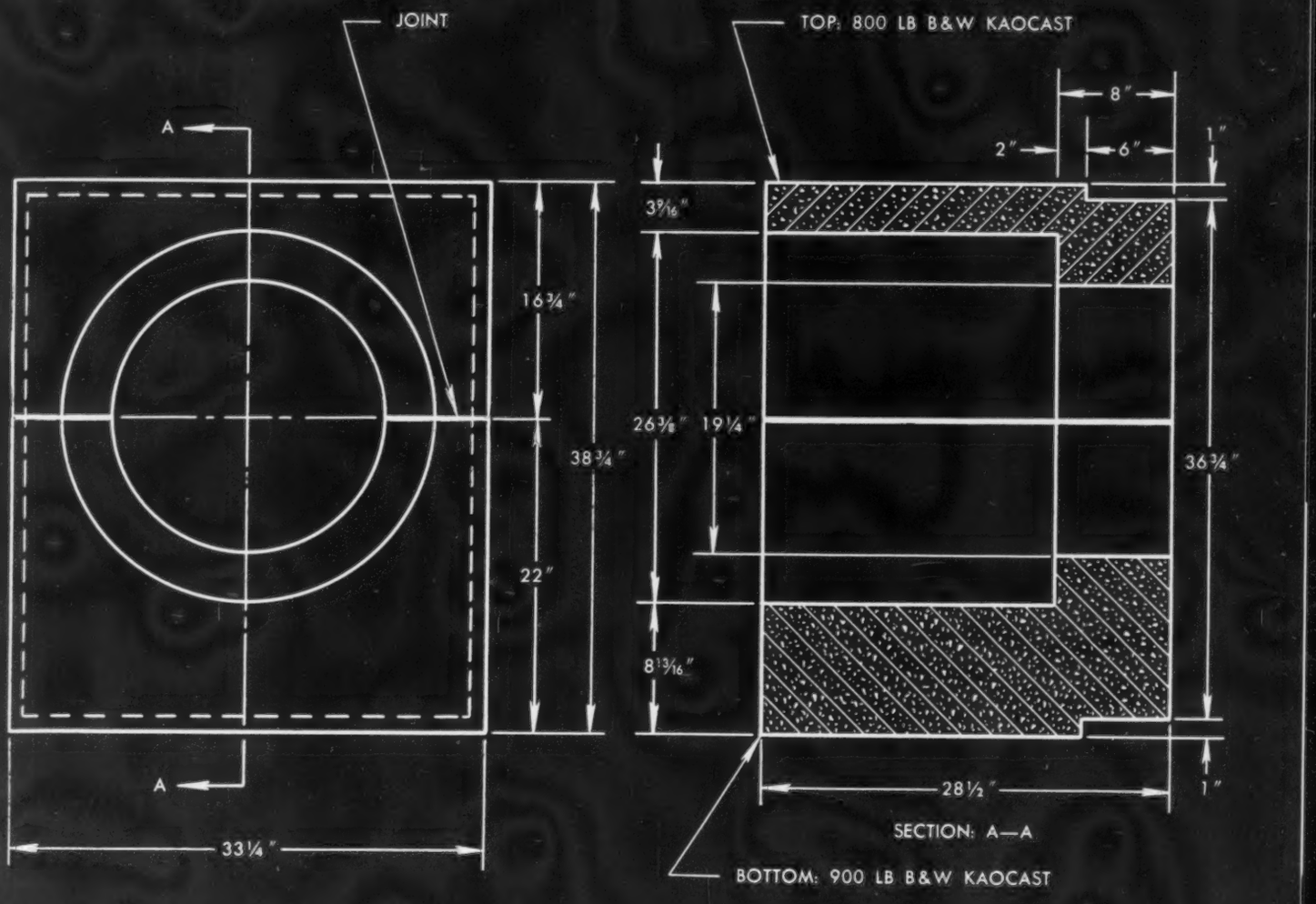
Office: *Youngstown* *Chicago* *Pittsburgh*

Tin Shearing Line Installation



66" Coil Preparation & Recoil Line Installation

Ore Bridge Installation



Inland Steel uses B&W Kaocast for burner blocks

The Inland Steel Company, Indiana Harbor, Indiana, has used B&W Kaocast for burner blocks in their Surface Combustion soaking pits since 1952. The average life of these Kaocast blocks has exceeded that of any other refractory material tried in this application.

These Kaocast blocks, which weigh 1700 pounds each, are cast in two sections, as shown in the illustration: 800 pounds of B&W Kaocast are used for the top section, and 900 pounds for the bottom section.

Kaocast is particularly suited to burner block applications because of its unusual volume stability, spall resistance and refractoriness. B&W Kaocrete-32 provides these same outstanding properties in temperatures to 3200 F.

Both B&W Kaocast and Kaocrete-32 eliminate the need for maintaining expensive inventories of special firebrick shapes. In addition, these refractory castables are versatile — they can fill your needs in many other plant-wide applications.

Send for your copy of new Bulletin R-42, "B&W Refractory Castables for the Ferrous Metals Industry." Write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

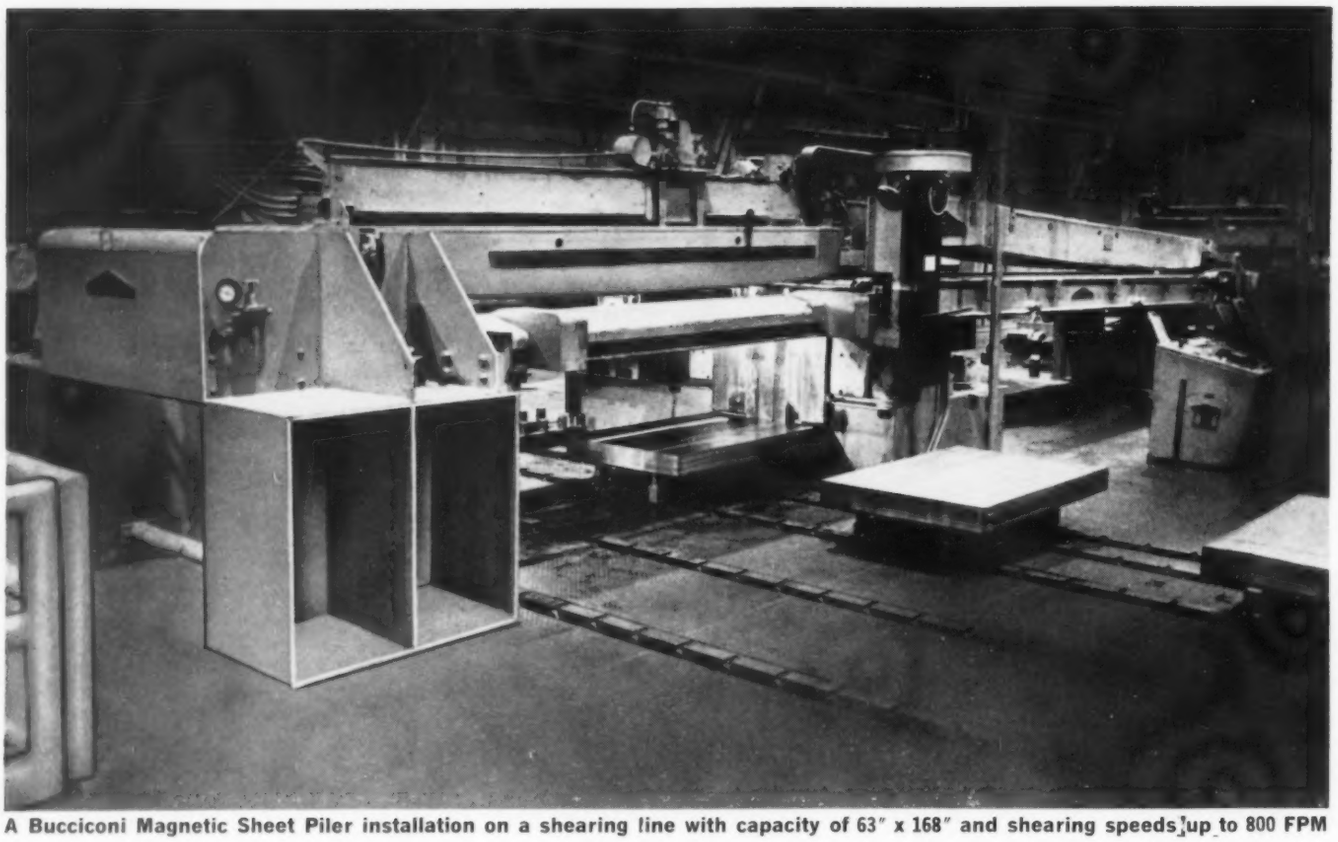
B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

R629

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.



A Bucciconi Magnetic Sheet Piler installation on a shearing line with capacity of 63″ x 168″ and shearing speeds up to 800 FPM

Magnetic Sheet Piler for Quality Conscious Sheet Producers

The Bucciconi Magnetic Piling Methods have been reduced to practice and progressively improved to provide machines for those producers who wish to give their customers the best in sheet quality with no damage to the sheets from piler operation. They are especially suited for long and heavy sheets, and for use in automation processes. For protection of your product, for speed of operation, for safety, and for dependability these magnetic pilers have no equal.

The Bucciconi Magnet Sheet Piler will pile sheets either by lapping them or as single individual sheets.

Sheets are received from the oiler or oiler by-pass conveyor by a short entry conveyor. An overhead magnetic conveyor, called the top lapping conveyor, drops the sheet on a magnetic belt conveyor, tail end first. The sheet is pulled down and held to the belt by powerful magnets. The bottom lapping conveyor feeds into the prime piler magnetic conveyor. Both conveyors travel at identical speeds, but considerably slower than the speed of the top lapping conveyor. The sheet is thus transferred from a high speed conveyor to a slow speed conveyor, and sheets are lapped in this manner.

The percentage of overlap of successive sheets is determined by the ratio of the speeds of the top and bottom lapping conveyor. A control is available to the operator so that he can obtain percentages of overlap from about 40 to 80 per cent. Thus with the shear at 800 fpm the actual piling speed at the delivery may be very low. A typical piling speed would be 200 fpm.

The Bucciconi Inductoswitch unit is used for controlling magnets where required, such as in the top lapping conveyor. This device is a magnetic proximity switch.

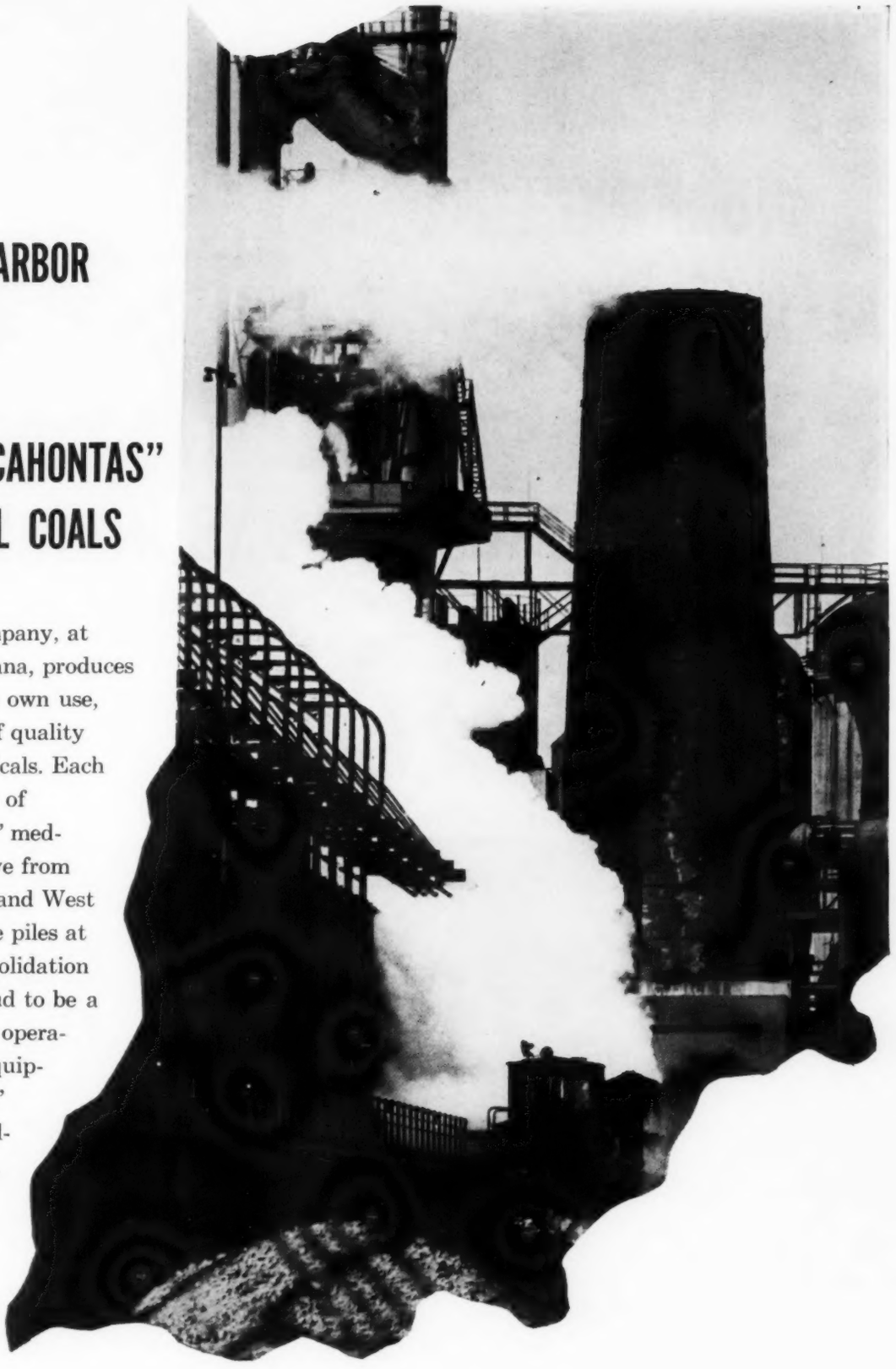
The advantage of this piler is that the sheet can be sheared at high speed and piled at a slow speed. Since the sheet is lapped by dropping the tail end first, and the final piling speed is slow the possibility of damaging sheets is kept to an absolute minimum. Sheets are held down firmly by magnets in the bottom lapping conveyor. The transition from high speed to low speed is done quickly and positively.

BUCCICONI ENGINEERING COMPANY INC.

PIONEERS AND MANUFACTURERS OF MAGNETIC AUTOMATION MACHINERY FOR HANDLING STEEL SHEET AND STRIP
MANUFACTURERS OF MAGNETIC CONVEYORS, MAGNETIC SHEET PILERS AND DE-PILERS, MAGNETIC ROLLS, MAGNETIC PROXIMITY INDUCTO-SWITCH, THE D. B. MICROGAGE, AND TIN PLATE ASSORTING EQUIPMENT.

899 GRANT STREET GARY, INDIANA, U. S. A.

AT INDIANA HARBOR INLAND STEEL USES "ORIGINAL POCAHONTAS" METALLURGICAL COALS



The Inland Steel Company, at Indiana Harbor, Indiana, produces top-grade coke for its own use, and a complete line of quality by-product coal chemicals. Each day thousands of tons of "Original Pocahontas" medium volatile coals move from the mines in Virginia and West Virginia to the storage piles at Indiana Harbor. Consolidation Coal Company is proud to be a major supplier to this operation, where modern equipment and "know-how" produce premium quality blast furnace coke.

CONSOL
ORIGINAL POCAHONTAS

POCAHONTAS FUEL COMPANY

DIVISION OF CONSOLIDATION COAL COMPANY

Cleveland • Chicago • Cincinnati • Detroit • New York • Richmond • Pocahontas, Va.
Bluefield, W. Va. • Salem, Mass. • Pittsburgh, Pa. • and other leading cities

Sales agents for Cunard and Bolt coals and Coalite briquettes

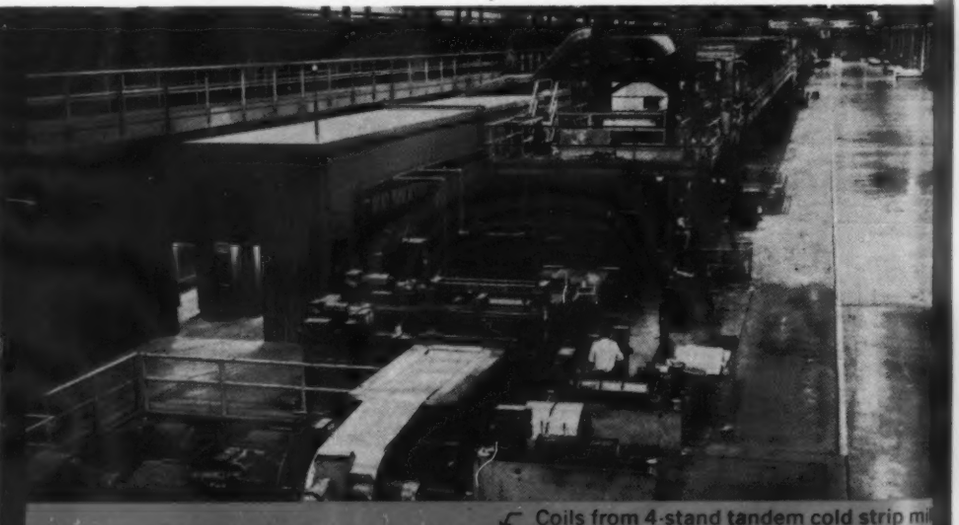
WORKING WITH INLAND® IN THE 1955-1958 PLANT EXPANSION PROGRAM

PROVIDING EXTENSIVE ENGINEERING OF CONSTRUCTION AND INSTALLATIONS

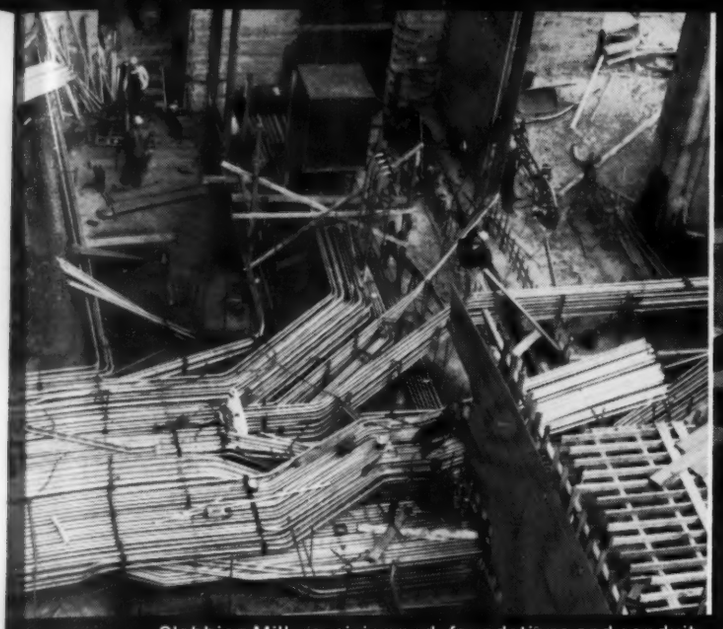
SWINDELL

Scarfer tunnel framework, Slab Mill

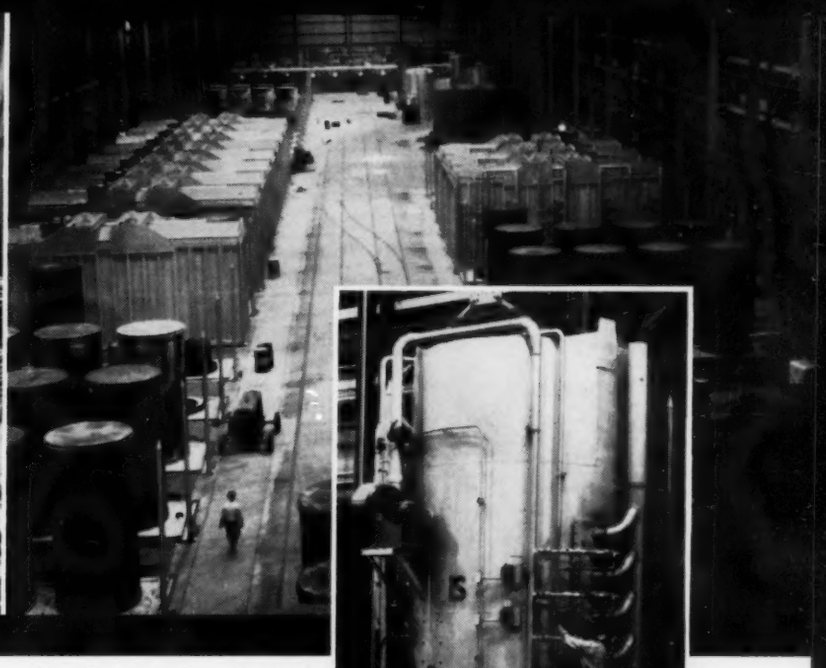
Cold Strip Mill, normalizing line, entry end

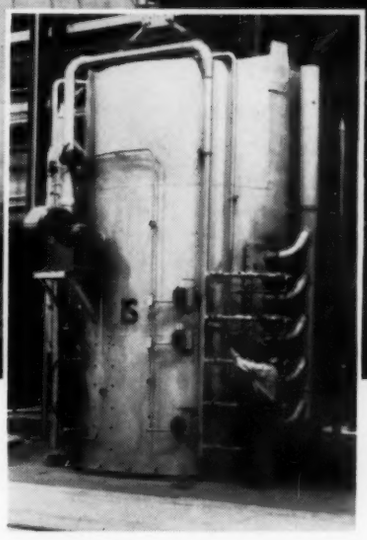


Coils from 4-stand tandem cold strip mi



Slabbing Mill, receiving end, foundations and conduit





No. 5 Annealing Department. 12 Swindell 4-stack furnaces with 36 bases; 4 single-stack furnaces with 12 bases.

The scope of Swindell-Dressler engineering for Inland Steel Company's great Indiana Harbor Works expansion ranged from the No. 3 Cold Strip Mill, to a 135-acre, 41-ft fill in offshore Lake Michigan, in water 25 feet deep.

-DRESSLER CORPORATION

Slabbing Mill, delivery side

Our work included the No. 3 Cold Mill Department with tandem and temper mill foundations, the pickling line, piping and electrical layouts . . . the No. 4 Slabbing Mill Department, with stripper building, soaking pits and other facilities . . . Coil Storage Building No. 3, with annealing department . . . the Normalizing Department, with 60″ continuous line . . . No. 2 Coil Storage and Finishing, with 63″ combination shear line . . . No. 3 Open Hearth, 3 furnaces, adding 730,000 annual ingot tons capacity . . . No. 5 Power Substation . . . and Electric Shop. In almost every case, our work included buildings, foundations, piping, electrical, cranes and other layouts.

• We are proud indeed of our association with INLAND—another great name in steel served by Swindell-Dressler.

ENGINEERING SERVICE: Swindell-Dressler Corporation provides a complete engineering service for the steel industry in the design and construction of new plants, and modernization of existing facilities. Consultations arranged gladly on request.

SWINDELL-DRESSLER CORPORATION

Engineers and Manufacturers

PITTSBURGH 30, PA.

The SWINDELL-DRESSLER CORPORATION of Canada, Ltd.

Ottawa, Canada

Hyde Park Rolls and Rolling Mill Equipment

Hyde Park Red Circle Rolls have served Inland Steel Company for years

ROLLS

Nickel Alloy Grain Rolls
Grain Rolls
Chilled Rolls
Nickel Chilled Rolls
Moly Rolls
Nodular Iron Rolls

All Grades Nickel Alloy Iron Rolls for Hot and Cold Rolling

ROLLING MILL EQUIPMENT

Bar Mills
Merchant Mills
Roller Tables
Stretcher Levellers
Sheet Mill Shears
Special Machinery
Sheet and Strip Mills
Pinion Stands
Reduction Drives
Roll Lathes
Machine Work

CASTINGS

Furnace Castings
Heavy Die Castings
Bases
Housings
Machinery Castings
Slag Pots
Heavy Tool Castings
Floor Plates

Hyde Park "Red Circle" Rolls—*the workhorse of the strip mill*—are giving long, dependable service in ferrous and non-ferrous plants throughout the nation.

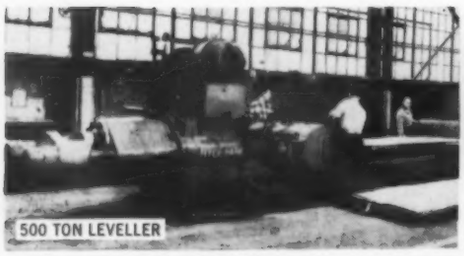
For *quality* and *tonnage* you can't go wrong with a "Red Circle" roll—there is one for every purpose.

And, in mills throughout the country, Hyde Park Rolling Mill Equipment is giving smooth, economical production at low maintenance cost.

Look for the "Red Circle"—it is the mark of quality.

Our engineers will be glad to work with you in the production of special equipment.

Gray Iron and Alloy Iron Castings up to 80,000 pounds.



500 TON LEVELLER

50" ROLL LATHE

MACHINE TOOL BASE PLATE

Hyde Park

FOUNDRY and MACHINE CO.

HYDE PARK, WESTMORELAND COUNTY, PITTSBURGH DISTRICT, PA.

4 MAJOR EXPANSIONS IN 4 YEARS

and each time Inland Steel calls on Worthington to help

Inland Steel Company's experience with Worthington equipment goes back some 40 years.

260 Items of Worthington Equipment

In 1919 the first Worthington compressor was installed in the Indiana Harbor plant. Since that time more than 40 additional Worthington compressors have been added. Also performing vital functions in the Indiana Harbor plant are almost 200 Worthington centrifugal, rotary, and reciprocating pumps, as well as 20 steam turbines.

With this background of experience, it was natural that Inland Steel should again turn to Worthington. To supply air for their four major expansions in the last four years, Inland Steel chose these Worthington compressors.

Location	Compressor Type	Total Horsepower
Sintering Plant	Y type	300 hp
Electric Shop	Y type	200 hp
#3 Cold Mill	Balanced Opposed	1200 hp
76" Hot Strip Mill	Balanced Opposed	600 hp

Products of Steel for Steel Making

Making steel is an exacting task which requires equipment with a high degree of dependability. That's why more and more plant operators are selecting Worthington for major items of power service equipment.

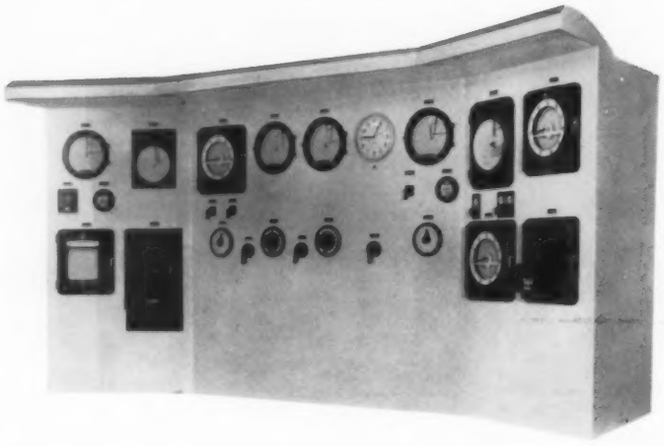
Making products of steel for steel making is one of Worthington's most important businesses.

Worthington Corporation,
Harrison, New Jersey 109-31

WORTHINGTON

WORLD'S LARGEST OPEN HEARTH SHOP AT INLAND STEEL

Complete Control Systems For 24 Furnaces Designed And Built By Fennell Corporation



ADVANTAGES

1. The right instrument for each function regardless of manufacturer.
2. Single responsibility from measurement to final control element.
3. Guaranteed performance of process.
4. All control centers completely wired, piped and tested before shipment.

OTHER FENNELL SERVICES

1. Packaged shop constructed furnaces
2. Fuel oil systems
3. General engineering
4. Combustion safety systems
5. Burner panels for special heating

Fennell Corporation

379 E. 147 St., Harvey, Illinois

in Inland Steel's No. 3 cold mill...

S-C VALVES PROVIDE PRECISE, DEPENDABLE CONTROL

of Taylor-Winfield flash-butt strip welder

Uninterrupted, high speed production of strip steel in Inland's new No. 3 cold mill is assured by the performance of Inland's Taylor-Winfield flash-butt strip welder in the pickle line.

Accurate control of the water hydraulic system actuating the welder's spacer bar and die cleaner, platen and clamping cylinders, and the hydraulic power supply pump by-passes is provided by piloted Sinclair-Collins diaphragm-operated control valves, handling working pressures up to 1,000 psi. A cam-controlled, modified S-C 4-way lever valve regulates critical burn-off and flash rates with consistent precision. Two S-C diaphragm-actuated valves, mounted end-to-end on a common bonnet, afford near-instantaneous maximum flow of high-pressure fluid to supply the massive, rapid upsetting action required for a sound weld in the strip, ranging to .187 x 63 inches in section.

Sinclair-Collins valves, offered in a variety of types and sizes to 3 in. NPT, for low, medium and high pressure service to 6000 psi, could be the answer to your fluid control problems. Designed for oil, air, steam and hot or cold *raw* water service, flange or screw mounted, S-C valves assure leak-free performance . . . resistance to corrosion. The Stellite seats in S-C valves eliminate wire drawing, cutting and costly downtime. For detailed information on S-C valves, contact the S-C representative, the S-C field office nearest you, or call one of the Bellows or Valvair field offices, located in over 80 major industrial cities.

For more information, write for Bulletin SC-59. Address Dept. ISE-959, The Sinclair-Collins Valve Company, 454 Morgan Ave., Akron 11, Ohio.

The SINCLAIR-COLLINS VALVE Co.

AKRON, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

Other INDUSTRIAL DIVISIONS of IBEC: The Bellows Co., Akron, Ohio
Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio

8032

Soaking Pits adjacent to Inland's new Slabbing Mill No. 4. Austin work included heavy foundations, floor and tunnels, and installation of soaking pits with all equipment and mechanical services.

Stripper Building at Inland Plant No. 2. Austin work included foundations and erection of structural steel.

THE AUSTIN METHOD

THE AUSTIN COMPANY • ENGINEERS AND BUILDERS

MINING AND METALS DIVISION

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THE AUSTIN COMPANY LIMITED, MONTREAL AND TORONTO · COMPANHIA AUSTIN, SAO PAULO

Austin Serves Inland Steel Expansion

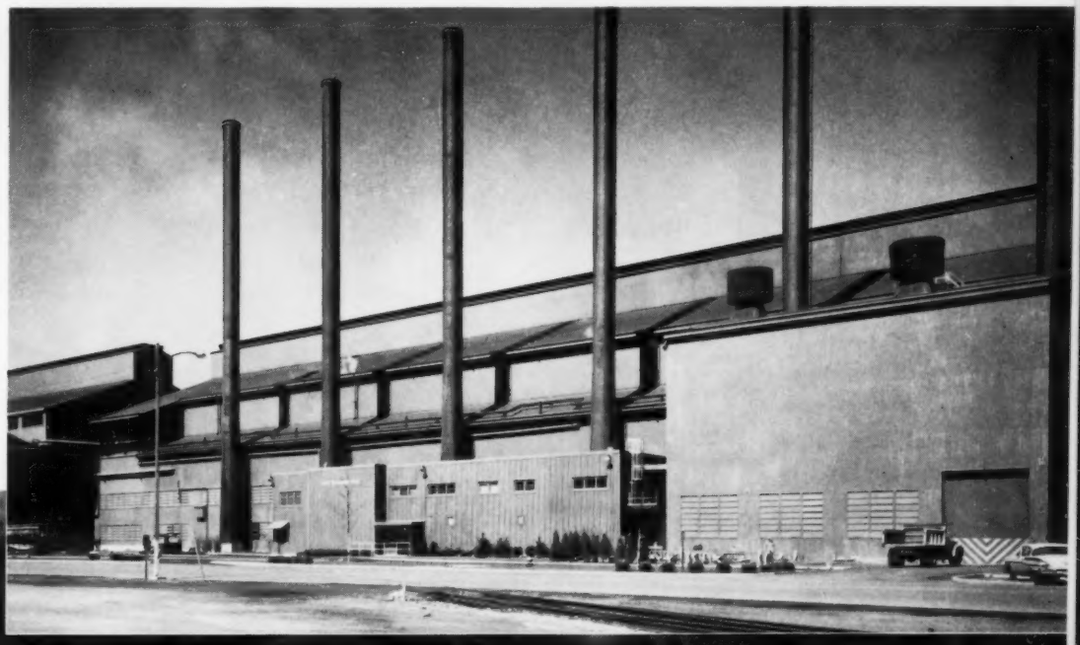
Over the past 10 years Austin has designed and built a wide variety of auxiliary buildings and facilities for Inland Steel which involved over 300 projects.

Austin projects have included a main office annex, locker buildings and plant offices for many operating departments, electrical substations, storerooms, laboratories and heavy construction as illustrated.

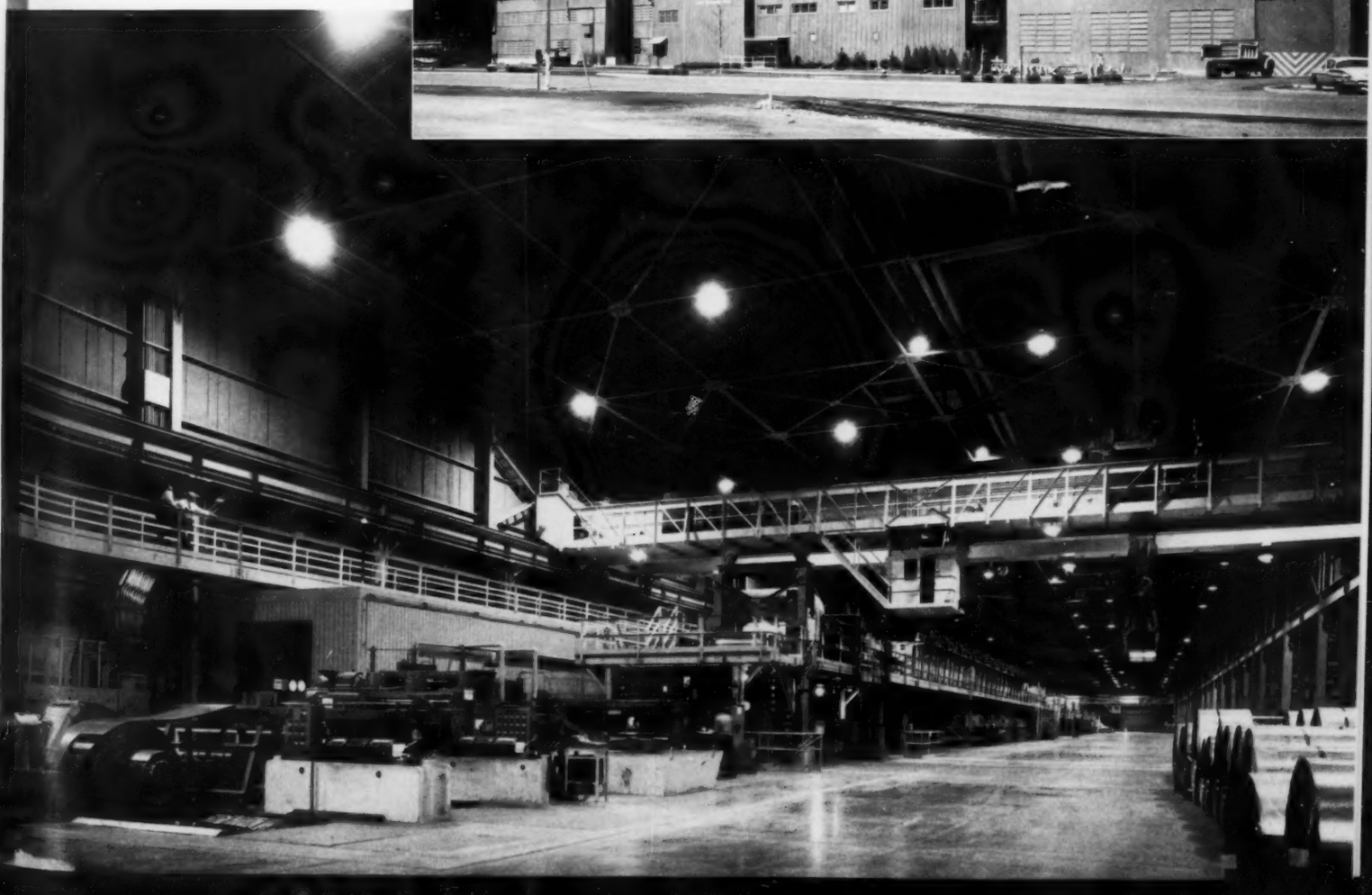
Austin Services for the Steel Industry include —

- Preliminary Estimates
- Preparation of Detail Drawings
- Purchasing
- Construction with Austin Forces
- Installation of Mechanical Equipment
- Structural Steel by Austin's Own Fabrication Division

Locker and Office Building for Inland's new No. 4 Slabbing Mill with water treatment building at right.



Normalizing Line in Inland's No. 3 Cold Mill where Austin's work included foundations, service tunnels, control house and erection of complete line, including piping and electrical work.



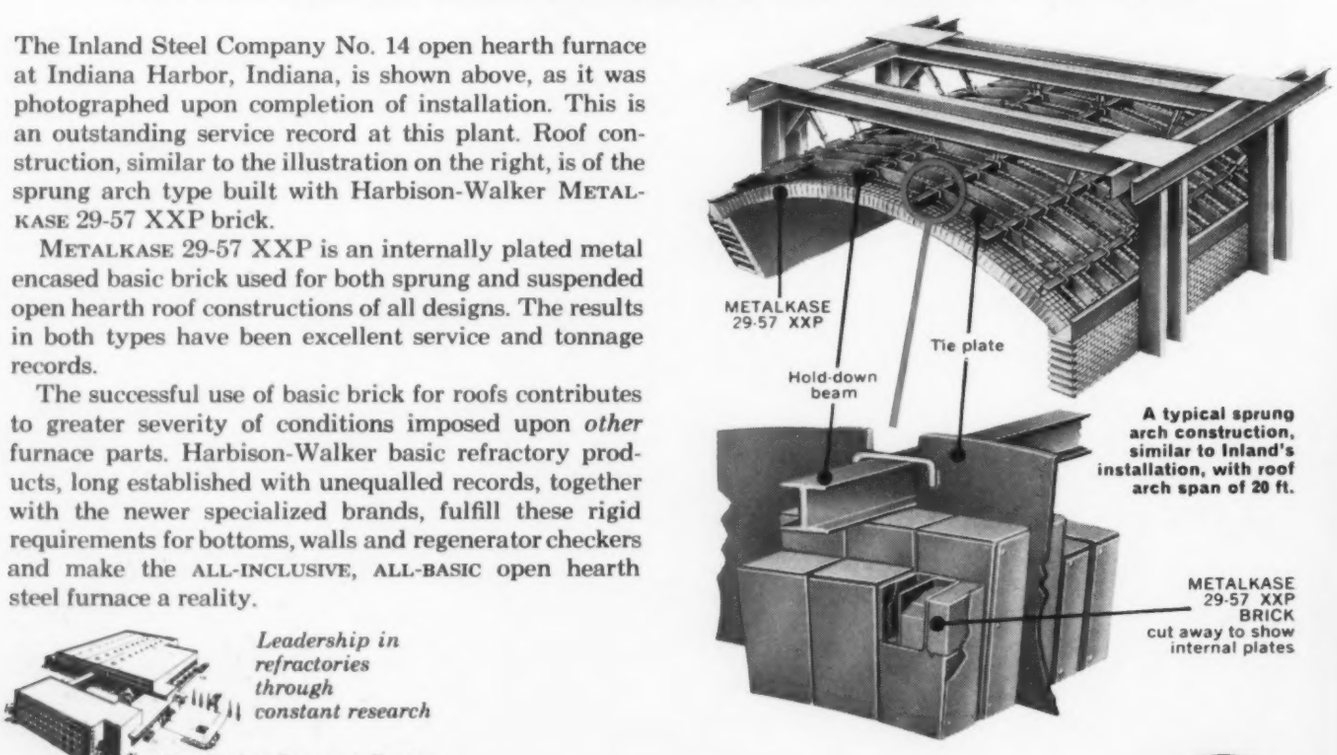
produced more than 500 heats of steel

with a Harbison-Walker Metalkase 29-57 XXP roof

The Inland Steel Company No. 14 open hearth furnace at Indiana Harbor, Indiana, is shown above, as it was photographed upon completion of installation. This is an outstanding service record at this plant. Roof construction, similar to the illustration on the right, is of the sprung arch type built with Harbison-Walker METALKASE 29-57 XXP brick.

METALKASE 29-57 XXP is an internally plated metal encased basic brick used for both sprung and suspended open hearth roof constructions of all designs. The results in both types have been excellent service and tonnage records.

The successful use of basic brick for roofs contributes to greater severity of conditions imposed upon *other* furnace parts. Harbison-Walker basic refractory products, long established with unequalled records, together with the newer specialized brands, fulfill these rigid requirements for bottoms, walls and regenerator checkers and make the ALL-INCLUSIVE, ALL-BASIC open hearth steel furnace a reality.



A typical sprung arch construction, similar to Inland's installation, with roof arch span of 20 ft.

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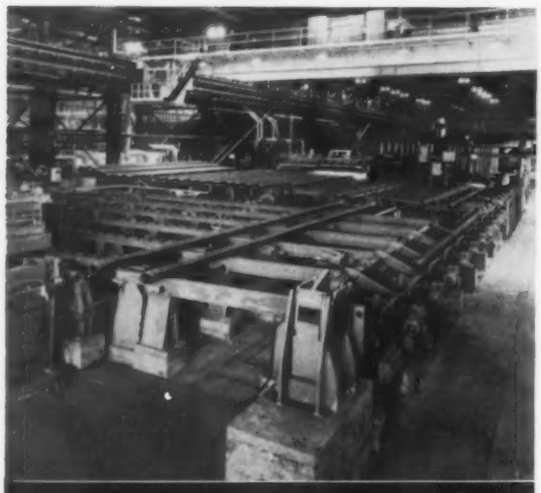

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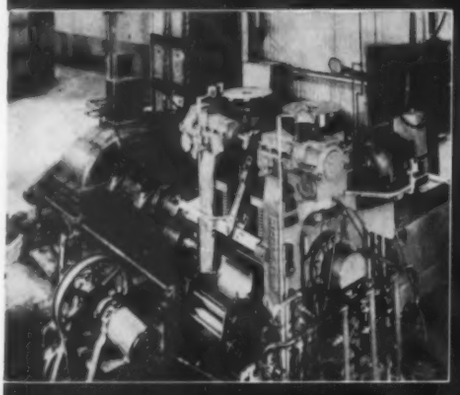
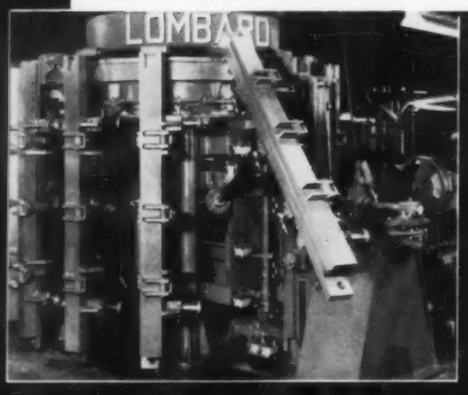


FOUR-HIGH ROLLING MILL



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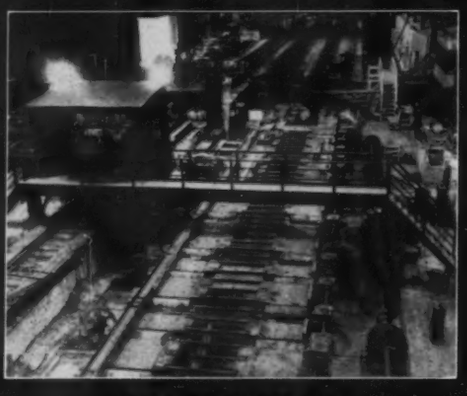
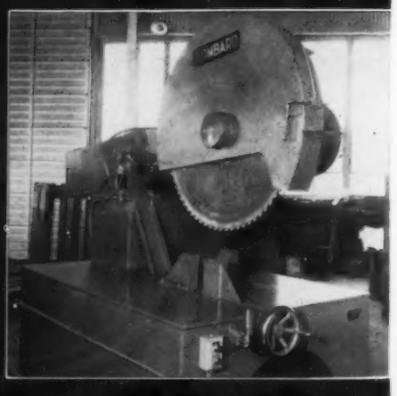
RING ROLLING MILL



BAR AND BILLET MILL



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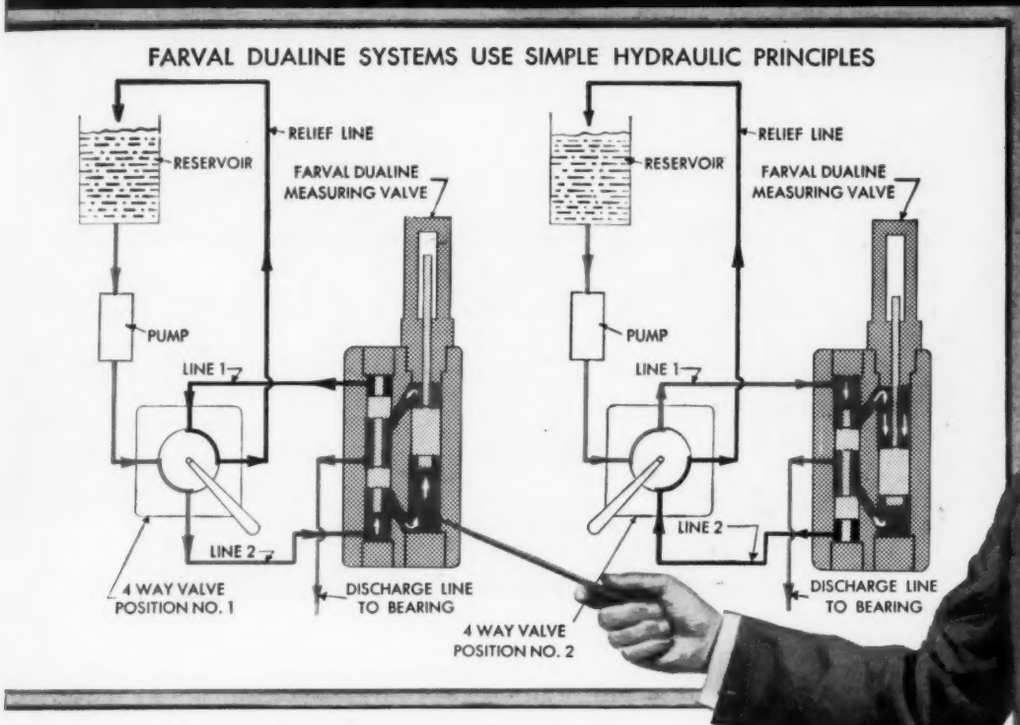

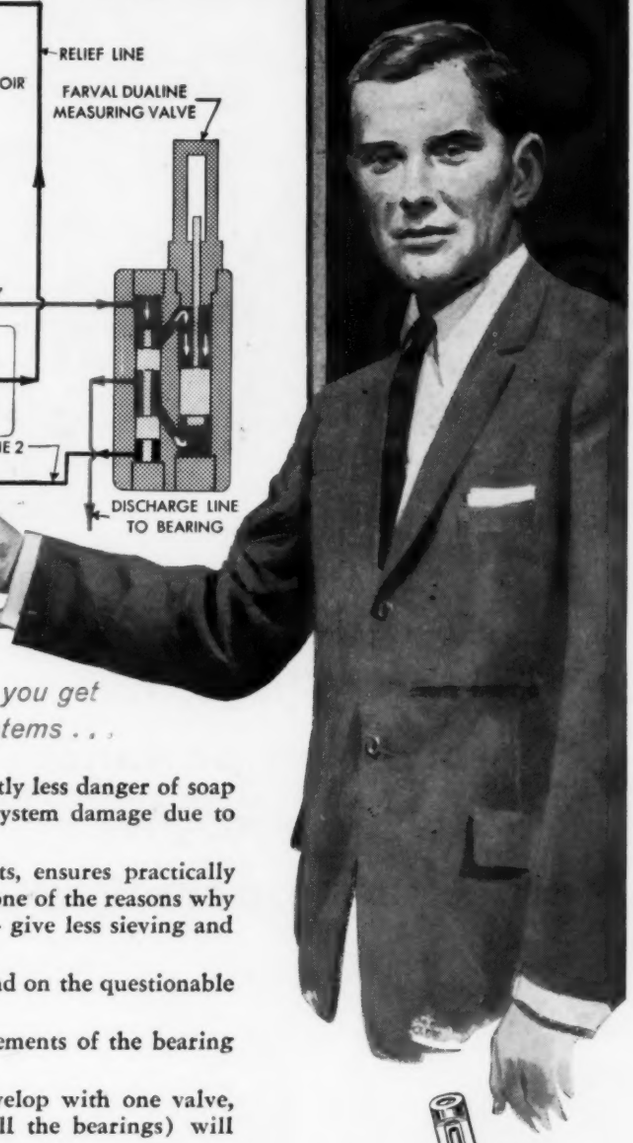

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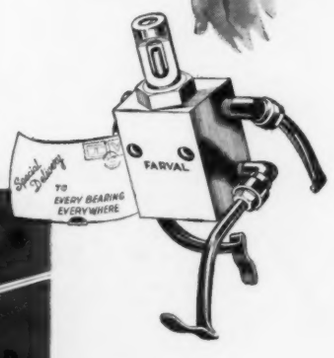

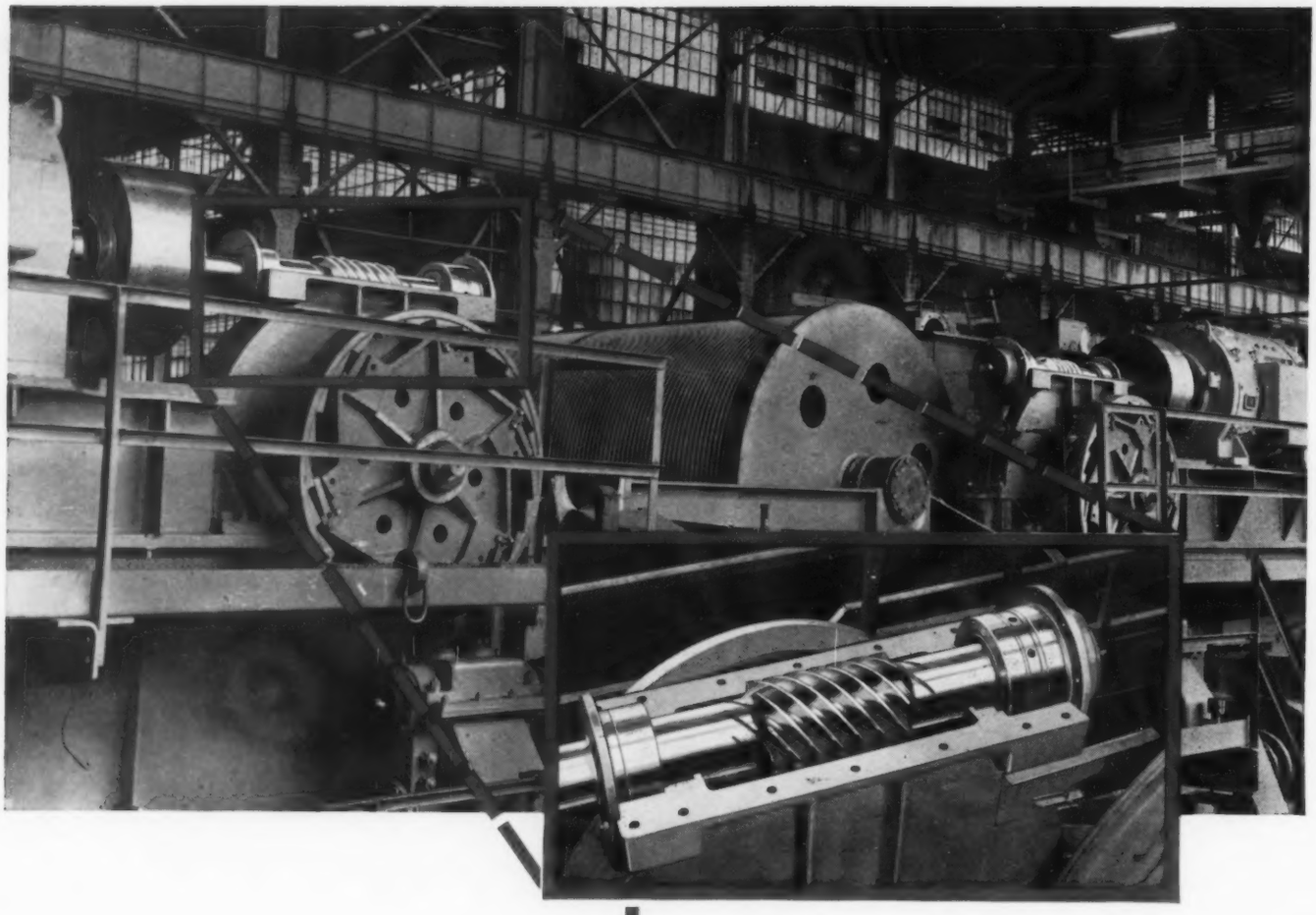

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Closed Circuit Television in the Fairless Works

by R. W. Sheffler,
Supervisor, Electrical Engineering
Fairless Works
United States Steel Corp.,
Fairless Hills, Pa.

. . . . this new tool is being used to assist operators in performing their work more effectively . . . .

DURING the initial design of Fairless works, the potential of a new operating tool in the form of closed circuit television was recognized. This new tool was utilized where processes could be simplified or operators could be assisted in the performance of their work.

Slab reheating furnaces—The charging of slabs into the reheating furnaces of the hot strip mill, Figure 1, was recognized to be an operation well suited for the application of industrial television. Here the operator is located in a strategic position to see all that is taking place on the entry side of the furnaces. He can spot slabs for pushing into No. 2 or No. 3 furnaces from his position in the pulpit. However, the angle of incidence for No. 1 and No. 4 furnaces is too great to allow accurate spotting of the slabs for pushing into these furnaces without the danger of damage to the refractory. By placing a camera in line with the edge of the furnace it is possible to spot the slab accurately in position before pushing it into the furnace.

The units chosen for this application used the image orthicon type of tube in the camera but the problem of local lighting was more critical than had been contemplated. However, a satisfactory picture was obtained by using four 300-watt sealed-beam floodlights for local lighting, and the operator can now accurately check the location of the slabs before pushing them into the furnaces.

Bloom and billet mills—In the blooming mill, after scarfing, the product is cropped and cut to length before further processing. The shear at this mill is equipped with a gage stop which will accommodate product in lengths up to 40 ft. When long cuts were required, it was necessary to run the blooms out beyond the gage stop and estimate the length of cut. Due to the

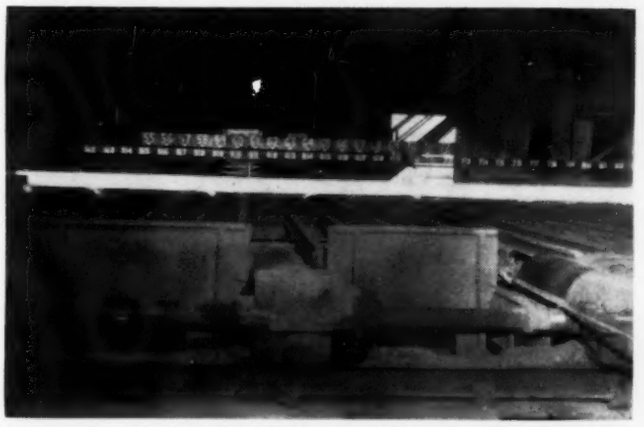


Figure 2 — In the application of television to over 40-ft length cutting of blooms there are two scales, the upper one shows the length of the bloom in feet and the lower one is calibrated to compensate for the angle between the camera location and the end of the bloom and is the one used for cutting a given length.

Figure 1 — The charging of slabs into the reheating furnaces of the hot strip mill was improved by closed circuit television.

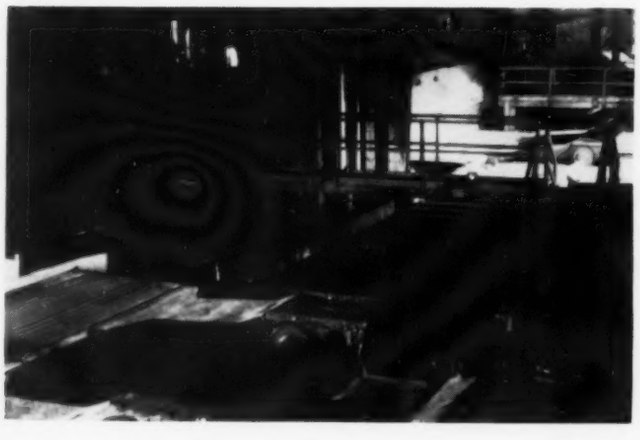


Figure 3 — Camera is on a motor-rotated mounting for focusing on the end of the bloom.

oblique angle of vision, shearing in this manner was very difficult without producing a great amount of waste. Placing a television camera directly across from the cooling beds permitted viewing the billet end at approximately a right angle, and much better accuracy in cutting long lengths of blooms was obtained. In this application there are two scales, Figure 2. The upper one shows the length of the bloom in feet, and the lower scale is calibrated to compensate for the angle between the location of the camera and the end of the bloom for cutting a certain desired length.

Since the cutting length varies from 53 to 85 ft, it is desirable to mount the camera on a motor-rotated mounting, Figure 3, so it may be rotated to focus the camera on the end of the bloom.

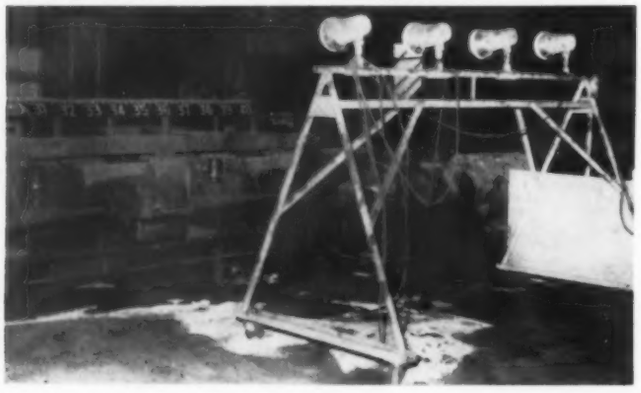
The local lighting for this application was mounted on the same assembly as the camera so it would rotate with the camera and floodlight the portion of the scale to be used for gaging the length of cut.

Keeping the camera clean and cool is of great importance. Therefore, it is enclosed in a cast metal protective housing, and compressed air is piped into the enclosure to dissipate the heat and maintain the camera clean by producing a slight positive pressure in the camera housing. A shield is installed to keep the direct heat rays from impinging on the camera housing.

After shearing, the bloom is then run through the 30-in. billet mill before entering the 21-in. billet mill. The product coming from the 21-in. billet mill is sheared on a flying shear and gathered on skew tables. The problems involved in trying to make accurate and consistent cuts on this shear requires constant alertness of the crew. The operator is located so far from the skew table he cannot see well enough to determine accurately the length of cut. Originally it was necessary to have a man at the skew table to confirm the length of cuts or signal the operator for a change in length.

By placing a camera using a 4-in. focal length lens with an F/2.7 aperture, directly across from the skew table the operator can observe the billets collecting on the skew table and determine accurately the length of cut. The local lighting problem for this application was very critical. Four 750-watt floodlights in a fixed location near the camera were tried first. Then we mounted them on the rotating assembly similar to the previous installation. The problem was finally resolved by placing the floodlights on a portable rack which can be placed directly at the side of the skew table, Figure 4.

Figure 4 — The lighting problem for the application of television to the shearing of billets was solved by placing floodlights on a portable rack alongside the skew table.



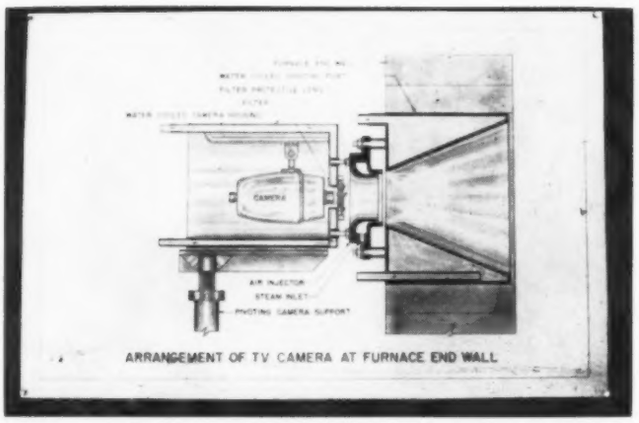


Figure 5 — Arrangement of a television camera in an open hearth furnace end wall.

The selection of paint color used for the background and numbers on the scales was difficult to resolve. The paint must withstand the intense heat of the billets and yet show up well in the monitor. A dull black color was finally selected for the background on these scales, and white colored numbers were used. However, the white on the painted scale soon darkened from the heat and mill dirt. A ceramic scale using raised numbers with the color baked on is now installed. This scale is not affected by the heat, and the accumulation of dirt can easily be wiped off.

The same type of camera housing and rotating mounting are used here as for the previous application, with compressed air used to purge the camera housing.

Open hearth—In the open hearth, closed circuit television consisting of camera, camera control unit and 21-in. monitor, is used to observe the bath and refractory condition inside one of the furnaces. In this application the most serious problem is that of protecting the camera from the furnace heat. The camera is mounted just outside the end wall of the furnace, Figure 5, positioned to sight through a water-cooled port set in the furnace end wall. Between the end wall and the camera is located a steam-operated air injector nozzle used to stop the blow of flame and spittings through the sighting port of the furnace. The camera is mounted in a water-cooled housing designed to shield the camera from the radiant heat of the end wall. A welding glass type light filter both protects the "Vidicon" tube from overheating and reduces the illumination to a value which can be handled by the tube. The filter is protected from furnace heat and spittings by a replaceable clear glass lens. The mounting of the camera and housing is arranged so that after once positioning the camera properly, the entire assembly may be swung away from the furnace end wall for inspection of the filter protective lens and repositioned without disturbing the original adjustment of the camera.

The television monitor permits observation of the actual conditions inside the furnace. Part of the roof is always visible; and when the furnace is empty, the bottom can be seen. Other items of interest which can be seen are the angle and the shape of the flame for various periods of the heat such as melt-down, ore and limestone additions, hot metal charge, and working period. A further advantage of the equipment is that it permits observation within the furnace at

times when the view is restricted by charging buggies in front of the furnace or by splashing which makes direct viewing through the wickets somewhat hazardous.

Many benefits are possible from the use of television in the open hearth furnaces: better furnace pressure control, improved oxygen usage at various fuel rates and fuel-steam ratio, and better control of flame characteristics if the furnace interior is continuously monitored. The use of television could improve furnace charge and addition practices for scrap, hot metal and ore and could lead to the development of roof protection against sweating and flame impingement. In general, the use of television should be a very valuable tool to the helper and melter, especially during those periods when it is considered unsafe for employees to observe the heat through the wicket holes.

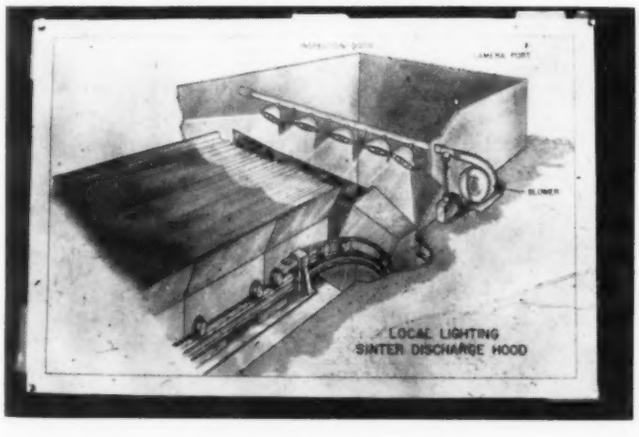
Consideration could be given to monitors in the superintendent's office and the foreman's office with push-buttons to enable them to select either end of any furnace on their monitor.

The objection to the moisture injected into the furnace by the steam nozzle or the cost of compressed air for accomplishing the same purpose are problems not as yet resolved for this application.

Sinter plant—At the sinter plant it is highly desirable that the operator spend most of his time in the vicinity of the control room where he has access to all instruments and controls. It is equally important that he get a good view of the sinter at the discharge end of the sinter bed to determine the quality of sinter and the extent of burn-through. By the use of closed circuit television, Figure 6, this information is transmitted to the control room to assist him in the operation of the line.

The equipment installed here consists of a rugged camera with a 16-mm focal length lens, using an F/1.8 aperture. The camera is mounted in a specially built air-cooled enclosure attached to the sinter machine exhaust hood with an expendable glass shield protecting the lens. Filtered air is blown into the camera compartment and is exhausted through a 4-in. round hole which serves as the lens port through which the camera observes the sinter bed. Positive pressure in the camera compartment keeps the dust from the sinter hood out of the camera compartment. A shutter drops down over the lens port if the cooling air is not on.

Figure 6 — A camera and necessary lights were placed at the sinter discharge hood so that the plant operator could view the final product from his control room.



The camera control unit is located in a motor room but is equipped with an additional filtered air supply. Filtering air in the sinter plant required extra precaution due to the conducting qualities of fine sinter dust. An expendable fiber glass pre-filter is used in conjunction with the rather expensive filter.

A 14-in. monitor is used at the camera control unit to allow adjustments to be made to the controls without the confusion of checking with the operator, and a 17-in. monitor is placed in the main control room in plain view of the operator. From this monitor he can determine the burn-through zone and the sinter product structure.

The problem of local lighting in the sinter discharge hood is especially difficult due to the dust layer which resembles a fog bank during night driving. After many trials, this problem was resolved by using five roadway type lighting fixtures with 400-watt mercury vapor lamps mounted in air-cooled reflectors. These are mounted on a pipe which is also used for an air duct, as well as a raceway for wiring. This assembly was placed just 18 in. from the sinter bed.

The air exhausts into the reflector through the mounting pipe and keeps the lamp sockets and the reflectors cool. The entire assembly is coated with an insulating refractory.

The tendency for ore and sinter dust to build up on the lamps surfaces was reduced by applying a heat treated silicone coating to the lamp bulbs prior to installation.

Considering the difficult application, the performance of the equipment has been good. The extra precautions for air cleaning and cooling add to maintenance, but they pay off in performance.

Even with the ultimate in local lighting it was necessary to install a special new tube in the camera. The results with this tube were very gratifying as high target voltage can be applied without edge flare spoiling the picture, and therefore the sinter structure can be observed without the glowing burn-through zone ruining the picture on the monitor.

Other applications—Many other applications have been considered and equipment demonstrated, but the results were not good enough to justify the expenditure at this time.

Docks—When unloading ships, the unloader operator has a limited vision of the hold in the boat where he is trying to work, especially for final clean-up. A view into the hold from the unloader operator's cab will show the difficulty of getting a good view of the work. It is now customary to place a man on the ship deck to signal the operator. However, a television camera placed at the side of the hold could indicate to the operator where the bucket is when he is working in a blind spot.

The difficulties involved in transmitting a satisfactory picture to the unloader operator, either through space or cable connections, and locating the monitor where the operator can see without looking away from his work, presented problems that were not easily resolved.

Slab mill—At the 45-in. slab mill, the pulpit straddles the mill table on the delivery side. In this location the massive structure of the vertical and horizontal mills, Figure 7, obstructs the roller's view of the ingot approaching the mill. A camera placed on the ingot scale and turn-around would give a good view of the ingot

approaching the mill. This would make it possible for the roller to use the manipulator and fingers better in controlling the ingot. Split or open end slabs could be seen by the roller and he could thus eliminate damage to the mill by interrupting the rolling when required. Finned ingots that hang up on the entry table could be more accurately maneuvered, saving time on the mill and temperature in the ingot.

An additional advantage could be gained by having a camera looking through the housing window. This would give the roller an excellent view of open end slabs, Figure 8, which would be an advantage to him if the open end starts around the table rolls or doubles under before going into the bite of the rolls. Locating the monitor in the pulpit where the roller could see it without taking his eyes from the screwdown dial indicator would be very difficult.

Figure 7 — The vertical and horizontal mills of the 45-in. slab mill obstructs the rollers view from his pulpit, located on the delivery side, of the ingot approaching the mill.

Figure 8 — It is desirable to have camera looking through housing window.

Figure 9 — A camera located at each roughing stand of a bar mill would give the operator a good view of the bar all the way through the roughing mill.

After the slab is rolled and passes through the scarfer, the operator is then in doubt as to the quality of scarfing on the under side of the slab. We have tried many cameras located under the exit side of the scarfer tables to inspect the underside of the slab. This is especially important on direct-rolled product as nozzle trouble on the scarfer may not be detected until several slabs have passed through the mill.

Bar mill—At the roughing end of the bar mill the operator is not able to see the bar from the time it enters the No. 1 roughing stand until it emerges from the roughers. A camera located abreast of these roughing stands, Figure 9, with a monitor in the pulpit would give the operator a good view of the bar all the way through the roughing mill, allowing him to detect trouble at the guides and make corrections to prevent cobbling.

Switchyards—The numbers of all railroad cars entering and leaving the plant railroad yard must be recorded. This is done by a clerk going out into the yard and manually recording the numbers. This could be done by the use of a closed circuit television system, thus saving time and inconvenience by allowing the clerk to stay at his desk and record the car numbers. A television system was tried at Fairless works for this application but was not satisfactory because occasionally a car would come by with a faded number which could not be identified.

The dispatcher for railroad movements is located in the transportation building, Figure 10, and has radio communication to all of the locomotives. There are 98 miles of track and 20 locomotives to serve the activities of the plant. The addition of television cameras at strategic points in the various yards may enable the dispatcher to utilize his motive power and rolling stock more advantageously and effect economies in their operation.

Gate surveillance—Fairless works has two outer gates and one inner gate in addition to the inner gate for National Tube Div.

The use of closed circuit television to assist in the surveillance of these gates has been considered. This application would consist of cameras looking both ways at gate No. 6, Figure 11, and a camera at the top of the railroad overpass, arranged to pan around to view all roadways, as well as cameras looking both ways at gate No. 8.

Cameras observing automobile traffic entering and leaving gates No. 6 or No. 8 would be monitored at the main gate. These pictures would be displayed simultaneously along with one of the over-all area on five console mounted monitors located at the plant protection office. Lights on this console would indicate when a car is at the gate. Controls on the console would open or close the gates as well as control the red or green lights. The pan controls for the camera at the overpass would also be located on this console.

At gate No. 6, during "gates open" time, the gates would be opened from the console and traffic lights set to "green." Automobiles could be observed coming and going but no attempt would be made to screen individual cars. If a traffic tie-up occurred, police could be

dispatched to the scene with the traffic lights set on "red" or the gates closed.

During "gates closed" times, the traffic light would be set at "red." As an auto drives over the hose at the approach to the gate, a light would flash on at the console. The guard observing the driver on the monitor could either set the lights to "green," which would allow the car to proceed and reset the gate warning light, or he could converse with the driver on the intercommunication system and learn the reason for his visitation to the plant. The guard would have complete control of the traffic lights and gates.

Gate No. 8 is only a single gate but would be controlled in a manner similar to that described for gate No. 6 with the in and out cameras indicating on the monitors at the console and full control for the guard of both the gates and stop-and-go lights.

In conclusion, experience to date indicates that only the rugged industrial type television equipment should be considered for most steel plant applications. The standard mass-produced units have provided entirely satisfactory operation in banks, toll roads and other applications where the service is moderate and atmospheric conditions ideal. Actual experience, however, in attempting to adapt these units to the rugged steel plant conditions has been completely unsatisfactory and, for future installations, only equipment properly constructed for the service conditions will be considered.

Figure 10 — The addition of television cameras at strategic points in the plant railroad system might enable the dispatcher to utilize his motive power and rolling stock more efficiently.

Figure 11 — Installation of a television circuit to monitor the plant gates has been considered.

Discussion

PRESENTED BY

H. W. POTTER, General Supervisor, Open Hearth Dept., Lukens Steel Co., Coatesville, Pa.

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E. C. CARROLL, DuBois Engineering & Manufacturing Corp., Hammond, Ind.

H. W. Potter: How many tons more per hour did you get out of the open hearth furnaces with the help of the television cameras?

R. W. Sheffler: We do not get any more steel out of this furnace as yet than we do out of the other eight, so I think it will be several years before your question is answered.

E. C. Carroll: I do not think we can emphasize too much what the author said in his conclusion about using *heavy duty* industrial television equipment for steel mill applications, the same as you always specify and use heavy duty mill type motors. I know the author is talking from experience.

When an industrial television application fails due to using light duty equipment it makes the next application just that much harder for you to sell to management—regardless how good your idea or application may be.

I feel the biggest field for industrial television is where yield can be increased. This is understandable because it means money in your pocket and it probably is easier to sell management on this type of application.

In our five or six years with closed circuit television, we have found many steel mill applications. We know there are many undiscovered applications. If you are to keep up with changing steel mill operations by using this new tool, it is going to be up to you to discover new applications and present them to management—much the same way as has been done at the Fairless works.

R. W. Sheffler: To comment a little more on the suggestion about heavy duty equipment, our research department is now setting up a project so we can encourage someone to build a heavy duty television type of equipment. I hope it will develop somewhat like the mill type motor, and we can use heavy duty equipment wherever advisable without worrying about atmospheric conditions or rough handling.

To comment a little bit more on the first application that we put in where we tried to justify the more expensive equipment—naturally one works under the surveillance of cost control—and it is pretty hard to justify the price difference in items you have to pay $4000 for and something that you can get for $2500. We did not make out so well on our first effort. It took us about two years to get that equipment where it would perform satisfactorily. After this experience we have enough background to demand the more expensive unit and justify our request as necessary to obtain proper performance. ▲

Application of Special Refractory Materials in the Iron and Steel Industry

by J. D. McCullough, Chief Engineer,
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. . . . many new special refractory materials have been developed for blast furnace, soaking pit, billet heating furnace, slab heating furnaces, and strip annealing furnace applications . . . .

IN the preparation of this paper, an effort has been made to avoid repetition of well known applications of special refractories. Since, however, all of the material presented has been proved in the field, it is inevitable that a certain portion of the information will not be new. It is hoped that in the aggregate there will be a sufficiently wide range of application coverage to provide some new thoughts which can be beneficial.

BLAST FURNACES

Lining—Within the past year or two, several plants have experimented with the use of gunned castable refractories to build up the thickness of worn blast furnace linings. One of the first such installations was made in October, 1957 with a castable which had a low iron calcium aluminate binder to resist the reducing atmosphere. No inspection has been made since the furnace went back into operation. A check made in February, 1959 indicated that, after 15 months' operation, no hot spots had developed. This may be taken as an indication that the gunned castable has proved to be performing its function satisfactorily.

Such a method of repair permits the furnace to be put back on the line with a minimum loss of production time and at a substantial savings over a rebricking. It is anticipated that this method of repair will find increasing acceptance as a maintenance measure.

Packing—A common practice when lining blast furnaces is to fill the 2 to 5-in. space between the outside of the brickwork and the shell with a loose material such as fireclay or granular insulation. During operation this material will frequently shift and settle, leaving voids. After a period of time, vertical channels are formed in this packing. Hot gases may work through cracks in the brick lining to these channels and travel up the casing. This results in reduced efficiency because the hot gases are doing no work, and also in hot spots on the casing, either because of the volume of the hot gases or because they may even ignite.

Several years ago, one of the large steel plants experimented with the use of a castable refractory instead of fireclay. Because of its concrete-like structure

Figure 1 — Approximately three or four courses of brick are laid after which the castable material is placed between the blast furnace wall and brick.

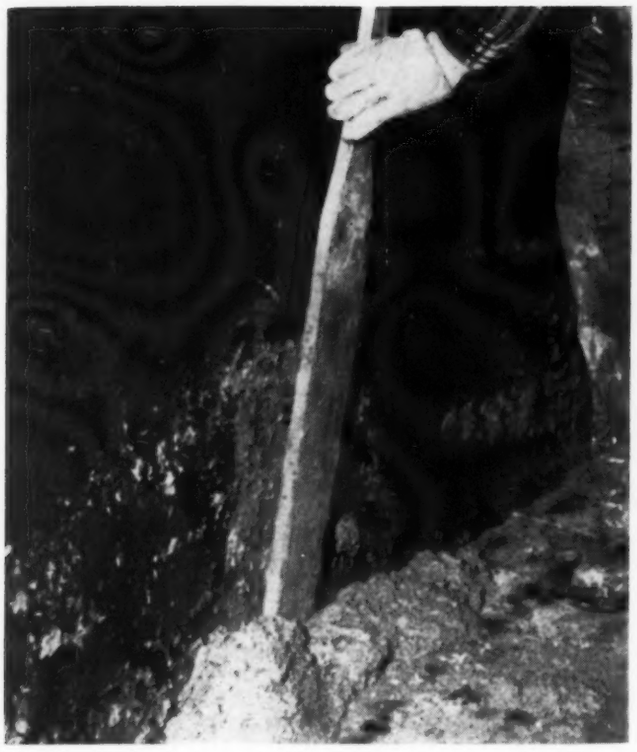


Figure 2 — After being placed as depicted in Figure 1, the castable refractory is tamped in place.

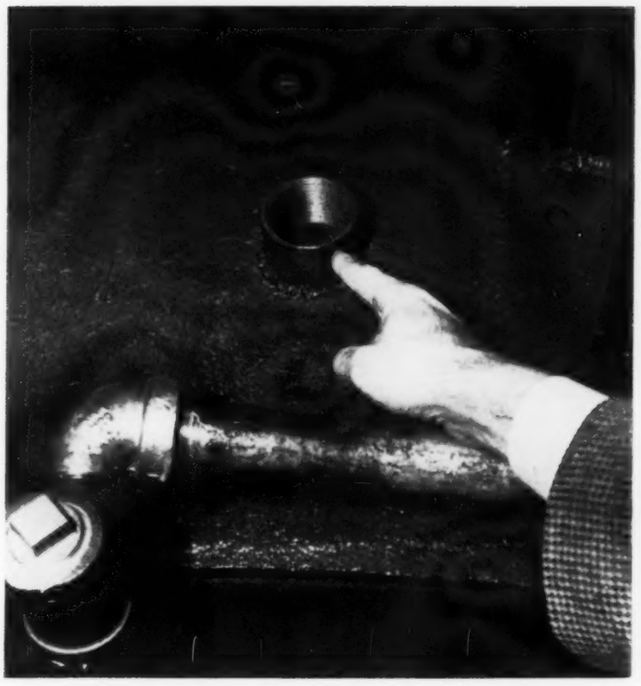


Figure 3 — These inside-threaded nipples were welded to the blast furnace shell to accommodate plugs to be inserted after all the water from the castable material has escaped through the drilled casing. Casing has not been drilled as yet.

it could not settle, and it was felt that such a material would prevent gas leakage. Operating experience proved this reasoning to be correct. All blast furnaces at this plant are now packed with a refractory castable as they need relining. The practice is becoming more common.

When packing with the castable, approximately three to four courses of brick are laid and the material is then placed in the space between the shell and the brick, as shown in Figure 1. It is tamped in place, as shown in Figure 2. In order to allow ready means for the water to escape when the furnace is heated, provisions may be made in the casing for venting. The necessity for this is a subject of debate among operators since the water from the castable can escape in the same manner as the water which is in the mortar used for laying the brick. Figure 3, however, shows a method used at one plant. A series of 2-in. pipe nipples were welded to the outside of the stack. After the castable had set up, a hole was drilled through the shell at each nipple. It was planned to put a pipe plug in the nipples after steam ceased appearing from the vent.

Castables for this service must be carefully selected. The material must not be affected by the reducing atmospheres or alkali vapors.

BILLET AND SLAB HEATING FURNACES

Hearths—Hearth materials in the soaking zone of billet and slab heating furnaces have been receiving increasing attention over the past several years.

A suitable material should: (1) remain volume stable under operating temperatures, (2) have minimum joints, (3) not react with scale, (4) be capable of resisting the abrasion to which it may be subjected, and (5) be economically justified.

Various types of materials, including bricks, plastics, ramming mixes, and castables of various base materials, are currently being used. Because scale gets into joints and creates a wedging action, the preference is normally for a monolithic construction instead of brick shapes.

As with many critical furnace sections, the results given by the refractory are dependent upon the manner in which the material is installed.

For the past several years, a 3200-F castable with approximately 66 per cent alumina has been performing successfully in both slab and billet heating furnaces.

To improve the resistance against abrasion, it is desired to obtain maximum strength and density. This can be accomplished by mixing the dry castable with a low water content and by thoroughly working it into place. Because of ease of installation, the average workman will usually add enough water to a castable to make a free-flowing soupy mix. This requires about 16 per cent water by weight for a typical high temperature castable (although there is a variation among different materials). By reducing the water content, however, and by thoroughly working the castable into place, the strength is greatly improved, as shown in Figure 4. This diagram shows that, for the castable in question, a reduction in mixing water from 16 to 12 per cent by weight results in increasing the strength by 68 per cent. In addition, the density is increased by six to seven per cent. Although such a mixture is very stiff and has little slump, it can be readily placed by means of a high-speed internal vibrator which causes the stiff mass to become of a jelly-like consistency and to flow almost like water. Figure 5 shows a hearth of a 3200-F castable being placed by vibrating techniques.

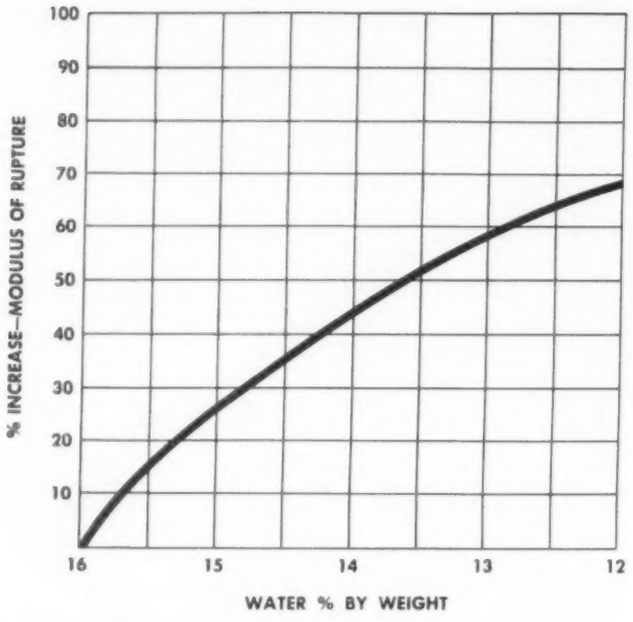


Figure 4 — The strength of a castable goes up as its water content goes down.

When using this castable it is desirable to install dry skids on 4 to 6-ft centers extending one to two in. above the surface of the castable. Even though the dry skids may wear down after a period of time, they permit the hearth to be fired to a high degree of strength before being subjected to abrasion from the billets.

Experience has indicated that scale can be removed readily from this material, whereas it tends to adhere to many refractories commonly used in this area.

Roofs—The use of monolithic roof constructions continues to gain steadily in acceptance. This is brought about by a number of factors. Among them may be listed: (1) elimination of a variety of special fired shapes, (2) ease and economy of installation, (3) excellent performance in service, (4) ease of repair.

A castable refractory of the 3000-F type employing a low iron calcium aluminate binder has proved itself excellent for this service.

Forms can be installed rapidly and inexpensively by use of tubular scaffolding or by suspending from overhead roof supporting steel.

Figure 6 shows an inclined section of a castable refractory roof being vibrated into place. Figure 7 shows this section after completion.

Figure 8 shows the condition of the roof, normally the zone of worst punishment, after two years' service. The white lines are expansion joints which had just been pointed up. It will be observed that there is practically no evidence of use. Figure 9, taken at the same time, shows the inclined roof section which guides the hot gases from the burners toward the hearth. This area is subject to flame impingement but shows no evidence of deterioration. After almost three years' service there is no essential change from these illustrations. The sidewalls have been replaced twice in this same period.

Repairs of roofs with castable refractories have been practiced for some time. In one method, corrugated sheets are inserted from above the furnace through the hole to be patched. The sheets are fastened to the overhead steel by wires. Anchor tile are suspended at the appropriate elevation from I-beams on approximately 12-in. centers. The castable refractory is then installed in the area to be patched. Since such patching is normally required only in zones subjected to severe service, the castable should have a 3000-F or 3200-F use limit.

Insulation of skid rail water supply pipes—Over and under heating of billets and slabs requires water cooling of skid pipes, with resultant drawbacks. First, the cooling requires large quantities of water, which is becoming an increasingly critical item. Secondly, a large amount of heat is lost to the water and is usually wasted. Thirdly, the cold pipes chill the steel, sometimes resulting in nonuniformity and slower heating. Different methods have been tried for insulating the pipes, some of which have been successful to various degrees. However, the search for something better is still going on.

A successful pipe covering should: (1) be simple to install, (2) be capable of resisting the combination of temperatures, scale and slag to which it is subjected, (3) be capable of taking the physical abuse to which it is subjected when accumulated scale is removed from

Figure 5 — A relatively dry-mix castable can be easily placed with a vibrator.

Figure 6 — An inclined section of a 3000-F castable refractory roof is being vibrated into place.

the floor, (4) not be affected by possible vibration of the water system, and (5) be economically justified by its ability to save fuel, increase production and give a satisfactory life.

A simple design of interlocking tile of fused mullite grain has been developed which shows considerable promise in answering all these requirements. Figure 10 shows a pipe protected with this type of tile after eight month's service. During this period, it was subjected to an average of one and one-half cold start-ups per week. Figure 11 is a close-up of the same tile. Note the base areas, indicating the resistance against scale adhesion. The scale build-up at the bottom of the pipe can be judged by the fact that only two tile can be seen below the bottom support plate. There are actually four tile in this location, two of them being covered with scale.

Figure 12 shows several pipes with relation to the burner, sidewall, and each other.

Figures 5, 6, 7, 8, 9, 10, 11 and 12 were taken in a billet heating furnace designed for a total input of approximately 100,000,000 Btu per hr.

The economics are worth studying. For purposes of convenience Figure 13 has been prepared. This table shows, first, the amount of heat absorbed per foot of height by a bare 6-in. pipe, double extra strong ($6\frac{5}{8}$ in. OD), when exposed to a mean radiating temperature of 2450 F with the average temperature of the water in the pipe at 100 F. The over-all conductance is assumed to be 0.9.

Next we see that if the pipe is protected by a close fitting tile 3-in. wide, the heat absorption can be reduced by more than 88 per cent.

The next step is to introduce insulation between the tile and the pipe. Such insulation must be capable of withstanding temperatures of 1700 to 2000 F and also remain resilient and efficient as an insulator. These characteristics are available in a ceramic fiber made from molten kaolin having a continuous use limit of 2000 F with higher peak limits. By proper selection of densities it has a thermal conductivity of approximately 0.75 for the mean temperature to which it is exposed.

With this material it is possible, by using only $\frac{1}{4}$-in. insulation, to cut the heat absorption to less than five per cent that of a bare pipe, and with $\frac{1}{2}$-in. insulation to cut it to less than three per cent.

An example has been worked out in Table I to show possible fuel savings with this insulation arrangement. By going through the various steps, it appears that a combination of tile and $\frac{1}{4}$-in. insulation on a 6-in. standard pipe could result in savings of more than $180 per year per ft of length under the assumed conditions. By taking available heat into account, the savings would increase, the amount being dependent on the temperature of the gases to the stack.

By having the possible savings, it is only necessary to know the installed cost to determine the economics. Similar studies can be made for any size of pipe.

As of the present time, this construction has been proved only on vertical pipes.

SOAKING PITS

Burner walls—Circular pits—On a large concrete construction job a lot of thought is devoted to the most efficient manner of materials handling to reduce

Figure 7 — This is the section depicted in Figure 6 after completion.

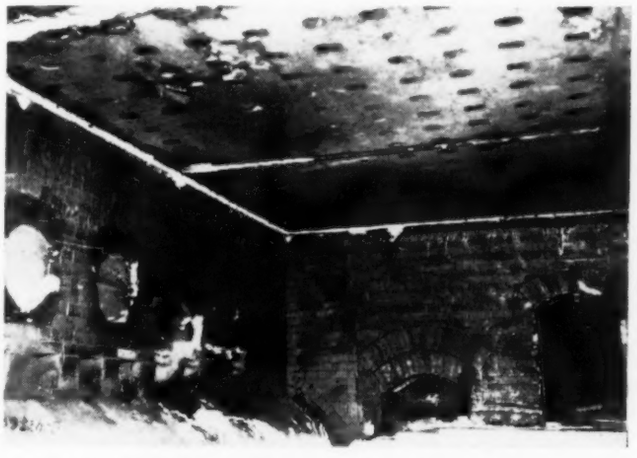


Figure 8 — This furnace has been in service two years. The roof in the burner zone shows practically no evidence of use.

Figure 9 — Although the inclined roof section guides the hot gases from the burners toward the hearth, it shows no evidence of deterioration after almost two year's service.

Figure 10 — Shown is a pipe protected by a simple design of interlocking tile, of fused mullite grain, after eight month's service in which it was subjected to an average of one and one-half cold start-ups per week. A burner opening is at the left.

man-hours. When equivalent planning is employed with castable refractories, which are essentially high temperature concretes, equally satisfactory results can be achieved.

Figure 11 — Closeup of the tile pipe in Figure 10.

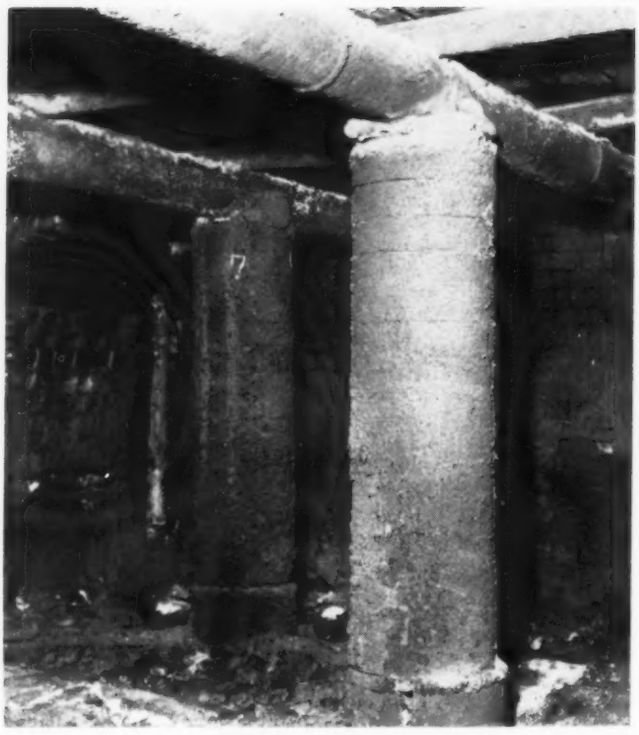


Figure 12 — This illustration shows several pipes in relation to the burner, sidewall and each other.

An example of good planning can be illustrated by the manner in which one steel company handles burner wall construction on circular soaking pits. A cross section and plan of a typical pit are shown on Figure 14. With brick construction it was necessary to periodically patch the burner openings, a rather time-consuming operation due to the necessary cutting and fitting.

In order to obtain longer life from the burner ports and to reduce the man-hours, it was decided to try a 3000-F refractory castable in the entire burner wall. After experimenting with methods on one pit, a technique of fast and efficient placement was developed.

A collapsible form of sheet steel was erected in the pit. Mandrels were placed at each burner to form the burner ports. A bulkhead was placed between two of the burners to give a surface against which to start the wall, as indicated on the plan of Figure 14. The castable was mixed in a mortar mixer on the operating floor to a stiff consistency. It was dumped into a hopper suspended from the top of the pit. A chute led from the hopper to

TABLE I

Estimate of Savings by Insulating 6 In. Double Extra Strong Water Supply Pipe with Tile + ¼-In. Kaolin Wool Fiber

Absorption per lineal ft of bare pipe per hr	= 191,500 Btu
Absorption per lineal ft of insulated pipe per hr	= 8,500 Btu
Savings per lineal ft per hr	= 183,000 Btu
Assume operation from 7 am Monday to 4 pm Friday (not including start-up time)	= 104 hr
Weekly fuel savings per lineal foot	= 104 x 183,000 Btu = 19,032,000 Btu
Assume fuel at $0.20 per million Btu Cash savings per week per lineal ft	= 19.03 x $0.20 = $3.81
Cash savings per yr per lineal ft (48 weeks availability)	= 48 x $3.81 = $182.88

Note—Effects of increased savings by considering available heat are not included.

PIPE SIZE DOUBLE EXTRA STRONG	6"	6"	6"	6"
PROTECTION	NONE	3" TILE	TILE + ¼" INSULATION	TILE + ½" INSULATION
ABSORPTION BTU/LINEAL FT	191,500	22,700	8460	5360
% ABSORPTION OF BARE TUBE	100	11.9	4.4	2.8

AVERAGE MEAN RADIATING TEMPERATURE ASSUMED AT 2450F
AVERAGE TEMPERATURE OF WATER ASSUMED AT 100F

Figure 13 — Heat absorption capacity by water supply pipes, with various insulations, in a skid rail system.

point of placement. The material was made to flow by inserting a high-speed internal vibrator into the mass of refractory castable. It was possible with the freshly mixed stiff material to form a dike several feet from the bulkhead to hold the fluid-vibrated material in place. Thus, the castable was installed to the full height of the bulkhead and around the mandrel of the first burner port. Then by placing freshly mixed stiff castable ahead of the area just vibrated, the first dike could be vibrated into a fluid mass and confined by the stiff material just placed. By continually moving the hopper and chute it was possible, in less than three hours, to form the entire wall with 12 burner openings, involving a total of more than 30,000 lb of material. This was accomplished with a 6-man crew.

From the diagram it will be noted that masonite strips were installed about nine in. deep between burner sections to take care of expansion and contraction. The material was permitted to burn out on firing of the pits.

After three years of operation, the original burner wall is still in service and in excellent condition. This method was originally developed for maintenance purposes, but was adopted for construction of new pits as they were installed. There are now ten pits at this plant which have been installed in this manner. No maintenance of the castable has been required.

Covers—Individual operators have definite opinions and preferences as to the most satisfactory type of refractory to be used in soaking pit covers. The most commonly used materials are castables, plastics and brick shapes.

In many plants, however, the installation of larger pits brings up a complication of crane capacity. To solve this problem there has been an observable trend toward an increasing use of insulating firebrick of the 2800-F grade. As an example of the considerable weight savings which can result, a 9-in. lining of insulating firebrick weighing 2½ lb each saved 24,000 lb as compared with super duty firebrick in an 18-ft diam circular cover, similar to that shown on Figure 15. In a rectangular turtleback type of cover 27 ft by 10 ft-5 in. inside the frame, the use of the same insulating firebrick permitted a savings in weight of approximately 20,000 lb.

Operating experience at a number of plants with modern pits has indicated that approximately the same life is obtained from kaolin base 2800-F insulating firebrick as from super duty firebrick. In addition, the lighter covers permit faster heat recovery. By taking advantage of this experience and by designing the handling equipment around the lower weight insulating firebrick, there are possibilities of reducing the capital investment required on new pits.

STRIP ANNEALING FURNACES

Hearths—The bases for strip annealing furnaces vary in construction according to the design of the

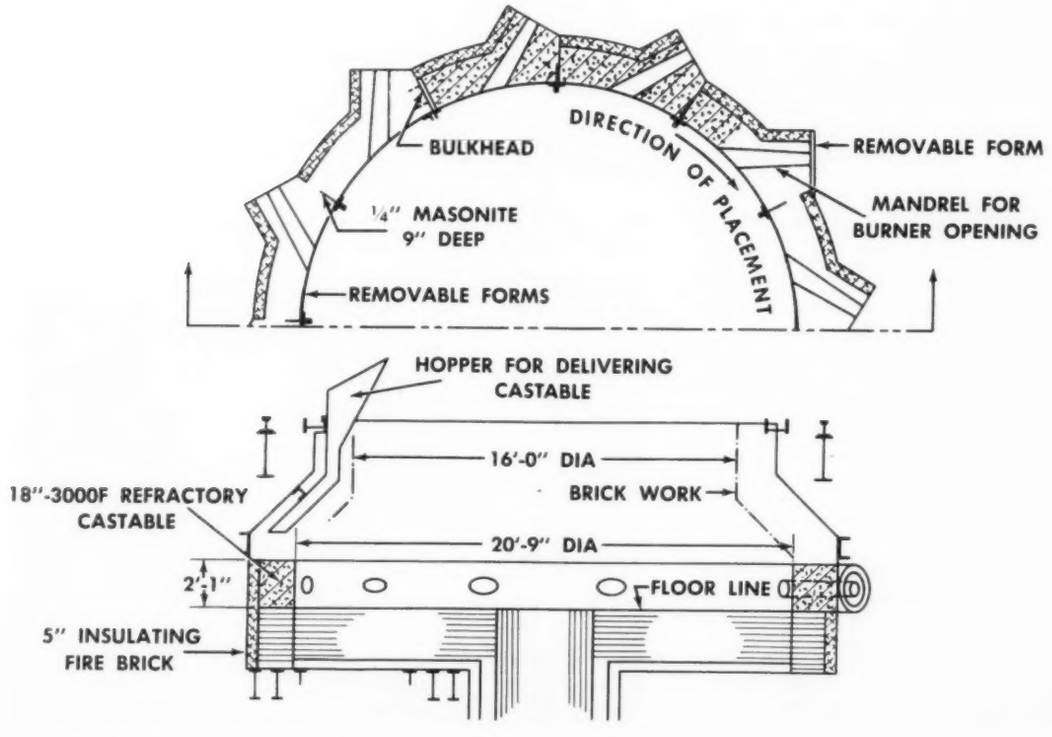


Figure 14 — Cross section and plan views of a typical pit.

Figure 15 — Crane tonnage capacity often puts a limit on pit size. This problem can be overcome, at least in part, by using insulating instead of super duty firebrick on the pit cover.

Figure 16 — This strip annealing furnace base handles a charge of 70 to 80 tons on a heating cycle of 24 to 48 hr with a cooling period of 48 to 96 hr.

various furnace builders. Furthermore, the designs are not static but are changed to incorporate improvements which operating experience indicates will be beneficial. The remarks under this subject have reference to older bases where improvements were incorporated as a part of regular maintenance procedures.

Figure 16 shows one of 16 bases having the approximate dimensions of 16 ft-6 in. long by 9 ft wide. They handle a charge of 70 to 80 tons on a heating cycle of 24 to 48 hr, with a cooling period of 48 to 96 hr. The atmosphere includes 7 per cent CO and 8.5 per cent H_2.

The bases of these furnaces were originally lined with firebrick. Certain drawbacks were encountered, however, such as gas leaks, disintegration of the brick by CO attack, and by sand entering the joints and causing a wedging action.

Several years ago, one base was completely rebuilt with a combination of insulating concrete topped with a dense kaolin base castable. Both materials were selected because of their resistance to attack by the CO atmosphere. The castable was installed in alternate sections to allow natural planes of movement on heating and cooling, but no expansion joints as such were provided. After a period of observation, other bases were converted to this construction as rebuilding became necessary. All 16 bases of this type are now converted in the plant in question, the oldest base having been in service five years.

Another style of base is shown in Figure 17. As can be seen, there are four circular platforms, each of which carries a coil of approximately 45 tons. The heating cycle is from 34 to 36 hr, while the cooling cycle is 68 to 72 hr. The atmosphere is similar to that in the previous bases.

The original construction of firebrick in the hearth and piers was subjected to the same difficulties as the first type of base described. Replacement of the firebrick was accomplished by the use of the same type kaolin base dense castable, which was resistant to the effects of the reducing atmosphere. Again the monolithic construction eliminated the difficulties experienced with brick. All 15 bases in this plant are now so lined.

This type of application is one which lends itself very well to gunning. There are no obstructions, and a hearth can be installed very rapidly and efficiently. The problem of material handling can be greatly simplified with this method of installation. Conventional methods, however, will give an equally satisfactory installation.

Curb walls—With certain types of bases, the curb walls are constructed of firebrick as shown in Figure 17. In some installations this construction is very satisfactory. In others, the tendency of the sand to work into the joints is a source of continual maintenance. Also, the firebrick may tend to disintegrate because of the effects of the reducing atmosphere.

These problems have been overcome at several plants by replacing the curb wall with a dense kaolin base castable not susceptible to the reducing atmosphere and capable of taking the physical abuse to which it is subjected. Experience has indicated that for best results, it is essential to anchor the castable to prevent pulling away from the casing.

This is another type of installation which lends itself well to gunning. By installing simple forms it is possible to eliminate the usual rebound loss. Conventional methods of installation are also satisfactory but require more man-hours. ▲

Figure 17 — Closeup of the castable construction of the furnace base of Figure 16.

Nuclear Energy Applications for Steel Plant Operations

by Patrick J. Selak, Manager, Nuclear Engineering Development,
and Rudolph Tietig, Jr., Principal Engineer,
Steel Plants Div., Kaiser Engineers, Div. Henry J. Kaiser Co., Oakland, Calif.

There are many possible applications of nuclear energy under consideration besides the present day use of radioisolopes in quality control.

IN the relatively short time since commercial application was first made of the significant and diversified potentialities of nuclear energy, the steel industry has probably been the principal supplier of structural and equipment material which comprises present-day nuclear facilities. Reciprocally the steel industry has benefited many ways through the use of nuclear energy.

Nuclear energy has been employed in developing a better understanding of steel plant operations and in improving operating techniques, and nuclear energy offers the potential of many new techniques. For example:

1. Nuclear radiation, through the use of radioisotopes, has provided new and improved methods for automation, process and quality control in steel plant operations.
2. Radioisotopes are used to determine the characteristics of material movements and reactor kinetics in steelmaking processes, thus enabling more efficient design and operation.
3. Nuclear energy may soon prove economically competitive with conventional means for providing process heat needed in the beneficiation, reduction and other steps involved in the production and fabrication of steel.

The purpose of this paper is to discuss the contribution which nuclear energy is currently making to the steel industry and the potential applications of nuclear energy based on our present knowledge of this new technology. Also discussed briefly are the complications attendant with the use of nuclear energy in the steel industry and the general precautions required.

SOME FUNDAMENTAL DEFINITIONS

Present and potential applications of nuclear energy in the steel industry are concerned with heat generated in a nuclear reactor and with radiation emanating from certain select radioactive isotopes.

A nuclear reactor is basically an assembly of fissionable material (such as uranium) in sufficient quantity and in a geometry which permits a continuous fissioning process or chain reaction. This nuclear chain reaction produces heat, neutrons and other radiation which serve many applications.

A radioactive isotope is an element in an unstable form which is transmuting, through the emission of radiation, into another isotope form or another element. The type of decay radiation of principal interest to the steel industry is the emission of beta particles (or electrons) and of gamma rays (or high-energy x-rays). These types of radiation can be measured quantitatively with measurement techniques differing for the highly penetrating gamma radiation and the less penetrating beta emission. Radioisotopes are generally produced in nuclear reactors through the absorption in nuclei of stable elements of neutrons produced by fission, or as by-products from the fissioning of uranium or other fissionable material. These latter radioisotopes are referred to as fission products and must be refined and separated in complex chemical operations before they are suitable for industrial application.

Radioisotopes can be used in industrial applications as a *source* of radiation required to perform a measurement function (for example, density) or to provide some irradiation service, and as a *tracer* to permit easy or ready analyses of the movements or reactions of materials which otherwise might involve extensive chemical or metallurgical examination.

Radioisotope sources and tracers are selected on the basis of "half-life" or specific activity, toxicity and ease of handling. The half-life of an isotope is defined as that time required for 50-per cent decay of the isotope to another form. Isotopes with long half-lives are desired for operations where infrequent calibration of instruments and/or measurements over a long period of time are required. A short half-life is required where a minimum of residual radiation is desired. The rate and

TABLE I
Radioisotopes Applicable to Steel Plant Investigations and Operations

Isotope	Emission and Energy (Mev)	Half-life
Carbon-14	β (0.155)	5580 yr
Sodium-24	β (1.390); γ (2.76, 1.38)	15 hr
Phosphorous-32	β (1.7)	14.3 days
Sulphur-35	β (0.167)	87.1 days
Potassium-42	β (3.58, 2.04); γ (1.51)	12.4 hr
Calcium-45	β (0.254)	152 days
Chromium-51	γ (0.32)	27 days
Manganese-54	γ (0.84)	10 days
Iron-59	β (0.46, 0.27, 1.56); γ (1.1, 1.29, 0.19)	45 days
Cobalt-60	β (0.31); γ (1.17, 1.33)	5.2 yr
Strontium-90	β (0.54)	28 yr
Yttrium-90	β (2.2)	64 hr
Caesium-137	β (0.52, 1.18); γ (0.662)	30 yr
Tungsten-185	β (0.43); γ (0.056)	74 days
Iridium-192	β (0.7); γ (0.201 to 0.605)	74 days

type of radiation by which radioisotopes decay cannot be altered by their chemical or physical form (solid, liquid or gas), or by any accompanying dynamic or kinetic effects.

Important radioisotopes which have been used or considered for use in the iron and steel industry are listed in Table I.

Radioisotopes are finding immediate application in steel plant operations. It is quite probable that in the future, nuclear reactors may be employed in integrated steel plants as a source of process heat and as a means of producing radioisotopes for use in process and quality control and other applications.

PROCESS STUDY AND DEVELOPMENT

Radioisotopes are currently being used to study:

1. *Type of movement of charge materials in the blast furnace*—Previously it was believed that the highest rate of charge material movement occurred at the periphery of the furnace. However, observations [1]* made by adding radioisotope tracers (e.g., Ca^{45}) to the burden indicate that the rate of movement actually is greatest at the axis of the furnace. Further, it was determined that the rate of movement changed considerably with the height of the furnace and that the maximum rate was found at the upper part of the furnace. Improvements in the design of the furnace profile and in operating procedures should result from these studies, providing increased production.

2. *Wear of refractory lining in the well of the blast furnace*—Refractory wear can be studied and controlled by introducing long half-life isotopes (e.g. Co^{60}) in the various layers of the refractory lining. By close observation of brickwork "burn-up," break-outs may be prevented; work stoppage and pig iron production losses minimized.

3. *Flue dust problems*—By using isotopes it is possible to determine which iron bearing materials in any given blast furnace burden produce the most flue dust. These studies are of considerable value in developing the most satisfactory charge for a furnace and in determining optimum beneficiation practices.

4. *Effect of slag stirring on rate of desulphurization of pig iron*—In order to clarify the rate-limiting step in the process of sulphur transfer from the pig iron to blast furnace type slag, radiosulphur (S^{35}) and mechanical mixing of the slag were used to study the rate and mechanism of desulphurization. It was found that the effect of the stirring increased as the temperature decreased indicating that the process is of a diffusion type [1].

5. *Thermodynamics and kinetics of metal-slag reactions (including desulphurization and dephosphorization) in open hearth operation*—One study, using a radiosulphur tracer, verified findings reported in 1926 that sulphur pickup by the metal was several times greater during melt down than during the refining period.

6. *Hydrodynamics of molten steel and kinetics of slag formation*—By utilizing isotopes of phosphorus and sulphur (P^{32}, S^{35}) it has been possible to determine with a high degree of precision the distribution of these elements between slag and metal in an open hearth furnace, thus providing a valuable means for slag control and of reducing melting process time.

Problems related to the uniformity of the bath are readily studied by use of radioisotopes. Thus, the mixing of liquid metal in open hearth furnaces and ladles as well as the dissolution of alloying constituents have been analyzed in order to determine the minimum time required between adding alloys to the bath and tapping the heat (for example, when radiation from added "tracer" ferrochromium becomes uniform throughout the bath).

In recent studies [2] of this nature it has been established that during the period of pure boiling, uniformity in the composition of the metal is achieved within 30 to 45 minutes for a 390-ton furnace. The optimum duration of the pure boiling period during melting in various capacity furnaces and for various grades of steel has been established. It has also been noted that during slag formation, the metal mixes poorly and uniformity of its composition is not achieved. Tests have also shown that metal motion is accelerated and the time taken for the composition of the metal to become uniform is reduced by artificial stirring in basic and acid open hearth furnaces.

Another study recently reported should be of interest particularly to the plants in the Birmingham district. This study employing radioactive phosphorus revealed that by alternating high and low carbon heats with a practice similar to that employed by Ensley, using tilting furnaces and a dominant slag pool, slag forming materials can be held to a minimum. Also of interest to Southern steel producers is the ability through the use of phosphorus and calcium isotopes to control and sort out the most suitable slag for the production of fertilizer.

7. *Scrap melting procedures*—By adding radioisotopes in the metal scrap, it is possible to determine the most satisfactory time to add hot metal as a function of the amount of scrap that has been melted.

8. *Steel contamination with nonmetallic inclusions*—By adding radioisotopes to the mold coating in steel ingot production, the presence of coating material as nonmetallic inclusions in the steel can be readily detected. As a result of such studies, contamination of metal has been reduced by testing various coating materials to establish those most suitable for ingot production.

9. *Weighing studies*—A rather novel application of radioactive cobalt and iridium (Co^{60}, I^{192}) is to determine the weight of metal in a ladle or even in a furnace. By placing the radioactive material in the metal and comparing the radioactivity of a sample of known weight taken from the metal with the total input activity the weight of the metal can be measured with an accuracy of about 2.0 per cent. Such a measurement, if made to the metal in the furnace, might be helpful in determining the weight of additions.

10. *L-D process applications*—In the L-D process, attempts have been made to correlate the dust loading in the waste gases with the temperature of the bath. The dust loadings were measured by means of a radioisotope gage in which the radiation source was located on one side of the hood above the furnace and a counter on the opposite side. The amount of radiation measured

* Numbers in parentheses refer to Bibliography at end of paper.

by the counter was an indication of the dust concentration.

In addition to the above which are reported investigations, one might consider the use of radioisotopes to determine or control the density of sinter; for determining uniform carbon distribution in the ladle when making high-carbon and high-manganese heats; for controlling the density, moisture content and coke breeze content of the sinter feed; to control the separation of tar and other condensables from coke-oven gas; for control of purity of by-products of coke plant columns; for measurement of the efficiency of coke plant by-product fractionating towers; and for determining diffusion of stack gases in the area surrounding the plant.

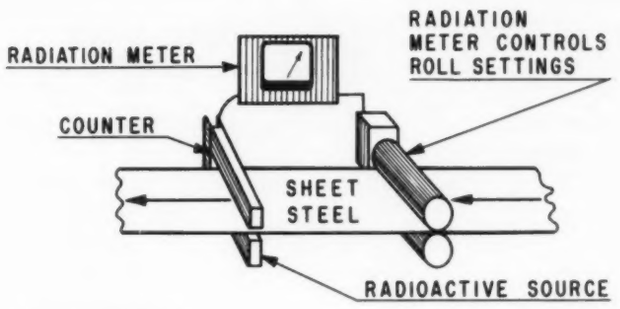
The foregoing uses of radioisotopes have been principally for the purposes of research and development. To the best of our knowledge these applications have not been employed in routine operations. However, it is quite likely that similar applications will eventually be used as a part of operating procedures in the not too distant future.

QUALITY CONTROL AND IMPROVED OPERATIONS

The main applications of radioisotopes that have become accepted as part of normal steel plant operations is in process and quality control. Probably the most common of these applications is in gaging and controlling the thickness of sheet steel. A schematic arrangement of how this might be accomplished is shown in Figure 1. The principle involved in this diagram is that any variation in the thickness of the metal will affect the amount of radiation coming through from a radioactive source. By connecting a radiation measuring device to the roll setting controls, the gage of the material leaving the mill can be accurately measured and desired thickness maintained. Tandem rolling mills throughout the steel industry are taking advantage of the automatic control provided by radioisotope-powered thickness gages. In certain of the heavier measurements gamma ray instruments instead of beta radiation are being used because of the greater penetration of gamma rays. An important consideration in rolling thin sheets of steel is to be able to measure it without contacting it which oftentimes destroys the sheet; the use of radioactive noncontact gages satisfies this requirement [3].

A second and familiar application involving quality control is found in a similar arrangement for measuring the thickness of coatings, such as, zinc coatings on galvanized sheets and coils, copper and brass coatings, etc. This measurement can be done two ways, either by continuously measuring thickness of the stock material and the coating at the same time during processing, or by the back-scatter principle measuring only the coating by the reflection process. This latter technique is shown schematically by Figure 2. The measurement of the coating thickness is determined by using light beta radiation to penetrate the coating only, the steel or iron stock reflecting the radiation back into an ion chamber on the same side as the radioisotope source. This measurement then serves as a means of controlling the amount of coating.

Another use of radioactive isotopes for quality



ADVANTAGES:

1-NO CONTACT-NO TEARING-NO MARKING MATERIAL
2-RAPID AND RELIABLE

Figure 1 — The most common use of radioisotopes is the measuring and controlling of strip gage.

control is that of radiographic inspection. Previously, this inspection was confined to the use of x-ray machines or radium. The new isotopes are vastly cheaper than radium, and are also less costly and much less bulky than x-ray equipment. They are at some disadvantage to the x-ray method in that they are slower and cannot be shut off.

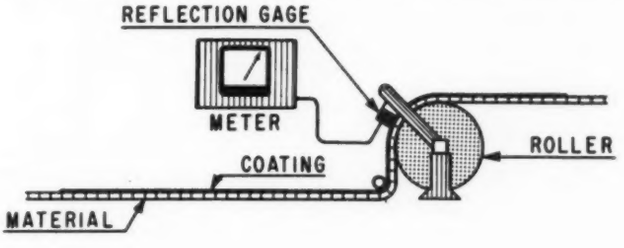
However, inspection of castings for flaws using radioisotope sources is becoming more and more routine in the steel industry. A typical example of radiographic inspection of a steel casting is shown schematically by Figure 3 where Co^{60} is placed on one side of the section to be inspected and a photographic film on the other. The exposed film indicates defects or other irregularities.

Furthermore, radiographic cameras are also being used to scan and check steel for blisters or bubbles resulting in much improved, more uniform products and lower costs.

In addition to quality control, many unit operations use radioisotopes for purposes of process control. For example, the measurement and control of liquid levels can be accomplished as illustrated in Figure 4.

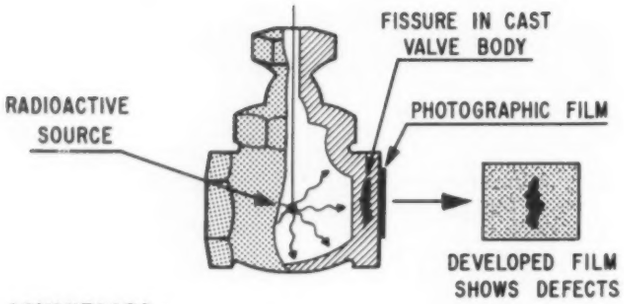
As noted in the schematic arrangement this method of measurement is not affected by corrosion from the liquid or by its temperature. Hence, it could be utilized even with molten steel or solids. The principle is simple and merely depends on the absorption of part of the radiation by liquid as it rises above the source of

Figure 2 — The reflection of light beta radiation from the coating of a strip can be used to indicate coating thickness.



ADVANTAGES:

1 - CAN MEASURE THICKNESS OF ANY COATING MATERIAL
2 - MEASUREMENT MADE FROM ONE ACCESSIBLE SIDE
3 - CAN MEASURE A VARIETY OF MATERIALS WITH ONE CALIBRATION



ADVANTAGES:

1-VERSATILE AND RELIABLE INSPECTION
2-INSPECTION MADE WITHOUT DISMANTLING
3-SOURCES OF DESIRED SHAPE AND SIZE
4-VERY HIGH ACTIVITY SOURCES AVAILABLE AT LOW COST

Figure 3 — A widespread application of radioisotopes is its use in detecting flaws in castings.

the radiation. Controls as close as $\frac{1}{4}$ in. have been attained.

Another application of isotopes that may be useful in steel plant maintenance is the possibility of locating leaks in pipe lines through their use. An illustration of this is found in Figure 5. As noted in Figure 5, a minimum of digging is required to locate and repair the leak.

POTENTIAL APPLICATIONS OF NUCLEAR ENERGY

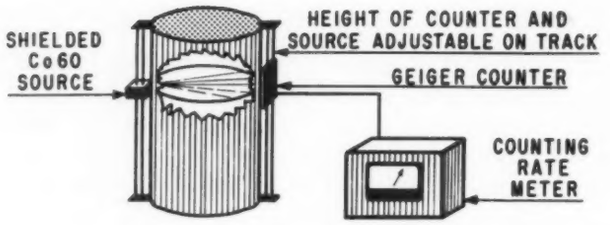
Needless to say, radioisotopes will continue to provide an important service to the iron and steel industry, and the authors are confident that many new applications of radioisotopes will be developed for the purposes of studying and improving existing operations. Thus far, we have said little regarding the use of a nuclear reactor in an integrated steel plant. It is conceivable that in the future all steel plants may be equipped with a nuclear reactor for the purpose of providing process heat and radioisotopes as well as possibly generating electricity.

The iron and steel industry consists of a large variety of processes, all of which require considerable quantities of energy in the form of heat (usually at a high temperature), mechanical and electrical power.

Table II [4] gives the energy requirements for an integrated steel plant producing the following weekly tonnages:

Coke	23,000
Pig iron	29,000
Steel ingots	44,000
Hot rolled strip	37,500
Tin plate	16,500
Cold rolled sheets	10,500

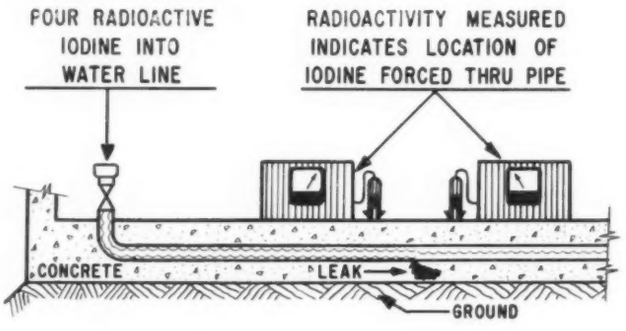
The difference between the process requirements and the by-products listed in Table II represents the additional energy that must be obtained from external sources. The table excludes the potential heat in the coal carbonized in the coke ovens and in the resulting coke charged to the blast furnaces. Assuming coal requirements of 34,000 tons per week, the total energy requirements would be increased to about 2100 megawatts of heat; or assuming that half of the coke would be used as a process material, the energy requirements



ADVANTAGES:

1-GAGE NOT AFFECTED BY CORROSION AND TEMPERATURE
2-CAN BE OPERATED BY NON-TECHNICAL PERSONNEL
3-ADAPTABLE TO AUTOMATIC RECORDING AND CONTROL OF LIQUID LEVEL

Figure 4 — Continuous indication of liquid level can be accomplished as shown.



ADVANTAGES:

1-NOT NECESSARY TO REMOVE FLOORS
2-LESS COSTLY AND MORE CONVENIENT
3-SHORT HALF-LIFE -- NO RESIDUAL ACTIVITY

Figure 5 — By pouring radioactive iodine into a water line and detecting the radioactivity along the ground, the location of the leak can be isolated.

would be about 1500 megawatts of heat and 600-megawatt equivalent of coke. These figures serve to illustrate the potential use of a nuclear reactor to provide the energy requirements in steel mills located in areas of high fossil fuel cost. For example, a nuclear reactor could provide the heat necessary for the hot air blast in a blast furnace operation as illustrated in Figure 6.

Of course, the construction of a reactor for heating the air blast alone might be hard to justify economically. Rather, such a reactor would have to serve many functions in fulfilling the energy requirements in a steel plant and in providing radioisotopes for use in the control of steel plant operations. It is even conceivable that as nuclear reactor material technology progresses, reactors might provide sufficiently high temperatures to drive heretofore impractical endothermic reactions. For example, if heat alone could be used to carry out the production of CO from CO_2, then the production of CO together with its use in reducing Fe_2O_3 to Fe could be performed in a closed cycle operation with savings in raw materials:

$$3\ CO_2 + \text{heat} \rightarrow 3\ CO + 1.5\ O_2$$

$$3\ CO + Fe_2O_3 \rightarrow 2\ Fe + 3\ CO_2$$

The use of nuclear energy, particularly for commercial purposes, is still in the embryonic stage of development, and as we learn more about how to

TABLE II

Process Requirements and By-Products of an Integrated Iron and Steelworks Expressed as Megawatts of Heat (Excluding Potential Heat in Coal Carbonized and Coke Charged to Blast Furnaces)

	Requirements				By-products					
	Heat	Steam	Electricity	Total	Gas	Tar	Benzol	Coke bream and breeze	Waste heat steam	Total
Coke oven and by-product	143	44	11	198	297	47	17	69	..	430
Blast furnace, sinter plant and lime kilns	209	44	24	277	557	..	..	35	..	592
Steel plant, soaking pits and slab mill	441	31	45	517	..	..	..	..	67	67
Reheating furnaces and hot strip mill	134	11	80	225	..	..	..	..	13	13
Cold mills, annealing furnaces and tin plate plant	52	52	142	246	..	..	..	..	..	..
Water Services	..	24	14	38	..	..	..	..	..	..
Boiler and power plant auxiliaries	..	31	7	38	..	..	..	..	..	..
Miscellaneous	11	16	17	44	..	..	..	..	..	..
Total	990	253	340	1583	854	47	17	104	80	1102

Source—Conference on the utilization of heat from nuclear reactors, Harwell, January, 1951.

utilize its potential, such postulations as above may become a reality and a significant part in future steel plant economics.

COMPLICATIONS ATTENDANT TO THE USE OF NUCLEAR ENERGY IN THE STEEL INDUSTRY

In using radioisotopes in steel operations, special precautions must be taken to insure that personnel cannot inadvertently become exposed to radioactivity levels above permissible human tolerance dosages which have been established by the U. S. Atomic Energy Commission and other qualified agencies. Further, operating procedures must be employed to preclude any radioactive contamination of the plant and environs. Thus, it would be desirable for a steel plant employing radioactive materials to establish a department responsible for the control of these materials, for establishment of handling and operating procedures, and for specifying equipment designs necessary to prevent contamination of the environs through the discharge of radioactive gaseous, liquid or solid effluents.

Special facilities will be required to prepare radioisotopes for plant use. Special containers will be needed to transport and store radioisotopes. Stack gases will have to be monitored and handled to prevent any airborne contamination from radioactive dust.

Steel products resulting from operations which have employed radioisotopes in direct contact with the reactants (for example, in investigative studies) and where the steel products may retain some radioactivity above normal, its end use would have to be restricted from those radiation-sensitive industries such as in

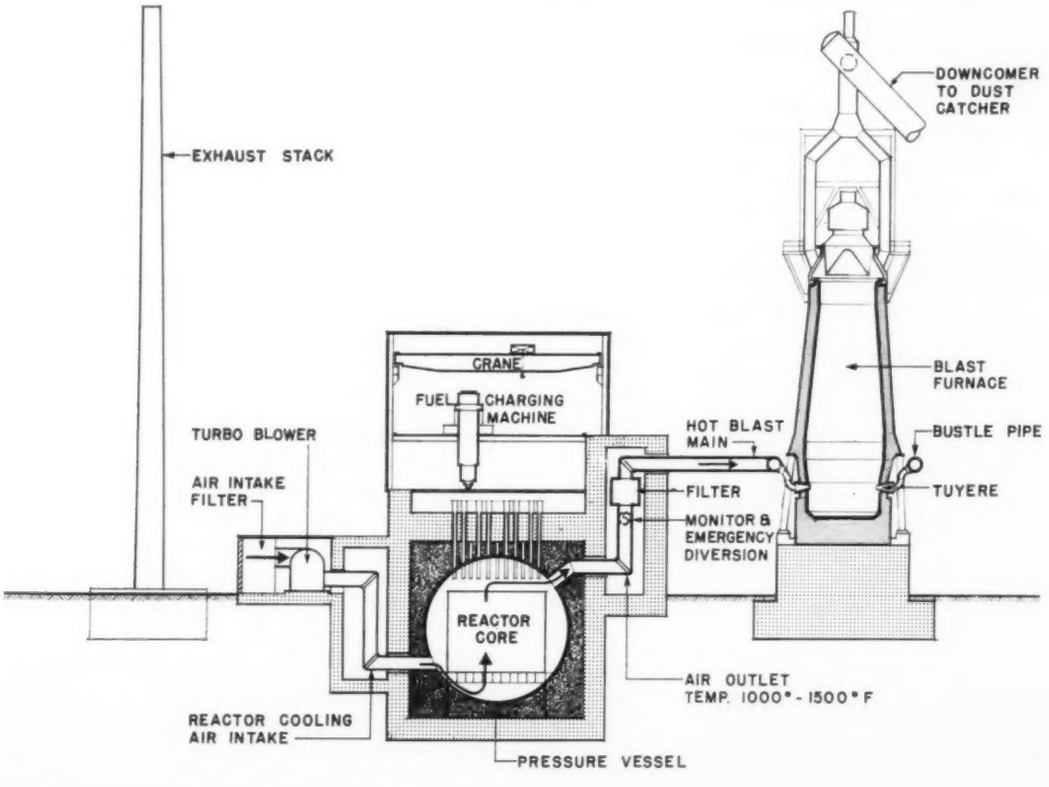


Figure 6 — A possible application of a reactor is to supply heat for the hot blast air going to the blast furnace.

the manufacture of photography equipment. Thus, it may be necessary to label such steel products for future identification and control.

SUMMARY

The iron and steel industry should not only continue to utilize nuclear energy sources based on existing techniques, but extensive research should be undertaken to develop other beneficial applications. At the International Conference on the Peaceful Uses of Atomic Energy held earlier in Geneva, a paper[2] on the use of radioisotopes in metallurgical research in the USSR revealed that in one investigation alone on the smelting of chromium steels, the use of radioisotopes to determine the minimum time for uniformity of metal composition resulted in an increase of metal output of "75,000 tons per year and a saving of 1,000,000 rubles in money" at the Kuznetsk Iron and Steel Works. Since the authors are not acquainted with this particular steel plant or in Soviet steel plant economics, we are unable to assess the significance of this gain. However, it does seem that radioisotopes and nuclear energy in general have much to offer the steel industry. It remains for the steel industry to take advantage of nuclear energy.

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Discussion

PRESENTED BY

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L. R. Stone: Republic Steel Corp. has had an active development program in nuclear applications for many years. We now have nucleonic laboratories at each of Republic's two research centers. At the Electromechanical Research Center, we have been faced with the practical problems of developing staff, facilities and projects. I would appreciate your comments on these problems as applied to steel men considering nuclear applications in their operations. In addition, I would appreciate your thoughts on the "time scale" for the application of nuclear reactors in the iron and steel industry.

Patrick J. Selak: In answer to your first question, I think as a starting point the steel company might employ a nuclear engineer or engineers acquainted with the application of radioisotopes and other sources of nuclear energy in metallurgical-industrial research and operations, and who have a ferrous metallurgical background. There are a number of such personnel currently working at the various AEC National Laboratories and other AEC nuclear operations.

With personnel of these qualifications, the steel company can proceed to develop an understanding of the potential applications of nuclear energy and the problems and operations involved in these applications. Another approach to this understanding might be through the medium of a qualified nuclear consulting firm. After acquiring this knowledge, the steel company can supplement his staff and facilities accordingly.

Now, in answer to your second question, the time factor involved in the application of reactors depends to a large extent on the future availability and cost of fossil fuels, and also in the development of improved reactor materials and technology.

This country is blessed with an abundance of fossil fuel resources and there has not been any incentive to develop nuclear industrial power or heat applications as there has been in other countries. However, I believe that well within the next ten years, the use of a reactor for the generation of relatively low pressure and temperature process steam will be economically competitive with conventional energy sources. In certain parts of our country this may be already the case. Within 15 years, nuclear electrical power should be competitive with conventional power in most parts of the country. In fact, it might be proved on paper that nuclear power is already competitive in New England, Florida and other areas where there is an increasing requirement for power in relation to expanding industrialization, and where the cost of fossil fuel is high (say, greater than $0.30 to $0.40 per million Btu).

Regarding high temperature reactors, say for the purpose of driving endothermic chemical-metallurgical reactions in the 3000 to 5000-F range, reactor component and structural materials will have to be developed to the extent that they are both economical and compatible with the nuclear requirements of a reactor. This achievement may be 20 to 30 years away. However, there are materials being developed and tested at the present time that can be used in gas-cooled nuclear reactors with outlet gas temperatures greater than 2000 F.

L. R. Stone: Do you agree that, in view of the time scale for nuclear reactors in steel operations, the steel industry should concentrate on gaging and tracing to obtain the maximum short range benefits of nuclear energy applications?

Patrick J. Selak: I agree with you.

L. R. Stone: Do you have any figures on how much some of the metal producing people are spending in tracer and gaging work and what some of their savings have been in connection with this work?

Patrick J. Selak: I am afraid we do not have much quantitative information regarding this subject at this time—other than a Russian paper presented at the recent Geneva Conference on the peaceful applications of atomic energy which reported increased production of chromium steel by 75,000 tons a year with savings of a million rubles through tracer investigations in one of their major steel plants. ▲

L-D Process for Making Basic Oxygen Steel

by E. J. Prince, Chief Operating Engineer, Steel Plants Development Dept.,
Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif.

Economic advantages of the L-D process over a new open hearth shop of comparable capacity are savings resulting from lower furnace refractory and fuel requirements and a saving of approximately three dollars per ingot ton for raw materials .... investment costs are fifty per cent less for a new plant.

THE basis of the L-D process of making basic oxygen steel is that of blowing high purity oxygen, vertically by a nozzle from above, onto molten pig iron contained in a suitable reaction vessel.

Oxygen—Oxygen is supplied at a purity of 99.5 per cent, and oxygen plants for L-D use are of 100 to 400-tons per day capacity. In order to insure getting nitrogen values in the steel in the range of 0.002 to 0.004 per cent, oxygen of at least 99.5 per cent purity must be used. Even if nitrogens higher than in this range are acceptable so that purities of less than 99.5 per cent can be used, it is usually preferable to generate all high-purity oxygen. A plant producing oxygen of one purity has better flexibility of operation, and there is eliminated the need for two separate pipeline distributions.

L-D furnace—The L-D furnace is fundamentally a refractory crucible provided with 360-degree movement for sampling, testing and tapping. Furnace lines are very important and a correctly designed furnace gives smooth blowing operations with freedom from slag slopping. In lance nozzle design, in furnace design and in general L-D plant design, the work is based on knowledge of plants where many thousands of heats have been made over a period of years, and information obtained from operating such plants all over the world is on file.

Pig iron—Molten pig iron is the most important charge constituent. Silicon, carbon, manganese and phosphorus, dissolved in the molten iron, are the fuel whose combustion by the oxygen provides the heat necessary to melt scrap and heat the metal and fluxes to a required tapping temperature. Satisfactory heat-to-heat results with regard to tapping temperature are directly related to the hot metal analysis. In some European plants, large hot metal mixers have been installed to help achieve uniformity in metal temperature and composition.

It is believed now that the process can be operated with all known metal compositions which contain sufficient carbon, manganese and silicon to provide the heat.

With regard to carbon, any amount is usable provided there is enough of the other heat-providing elements present so that the necessary temperature is attained after blowing. The range of silicon of pig irons used in the process is 0.1 to 2.2 per cent. Silicon of around one per cent which is normal for the open hearth process has given excellent results in the L-D process. In the early days of the process it was thought that the high pig iron manganese and the resulting high bath residual manganese were essential to top blowing with pure oxygen. The fear of over-oxidized steel from using low-manganese hot metal has been proved groundless. Operations at Aliquippa and Witten (in the Ruhr, Germany) have shown that hot metal having very low manganese can be used to make low carbon steels with no over-oxidation of the bath.

Phosphorus can be removed by one slag, using hot metal with up to 0.3 per cent. From 0.3 to 0.8 per cent, one or two slags may be necessary depending on the phosphorus per cent which can be tolerated in the finished steel. In Europe, high-phosphorus irons up to normal Thomas (basic bessemer) composition of 1.9 per cent have been used successfully in a modified L-D Process.

The new oxygen-lime powder process, originally known as the ARBED process, in which powdered lime is carried in with the oxygen gas is available to anyone taking the L-D license. This variation is particularly applicable to high-phosphorus irons and involves blowing a mixture of oxygen and powdered lime into the metal bath of the L-D furnace with the following advantages: (1) ease of dephosphorization from any initial phosphorus content; (2) less need for fluorspar or other flux; (3) no foaming from high initial silicon; (4) much lessened production of fumes; (5) longer lining life.

Usually, there is at least one-third less sulphur in the bath at the end of the blow than was contained in the hot metal charged, but this varies with the initial hot metal sulphur. Sulphur elimination is promoted in the process by the high temperature and vigorous slag-metal interaction under the lance. There is no sulphur entering from fuel. Sulphur actually leaves the system in the furnace gases.

Scrap—Scrap, which is used as a coolant may, in the process today, varies from turnings to scrap ingots. Wherever residuals can be tolerated, the furnace will handle bought scrap of inferior quality much more successfully than in the open hearth or basic electric arc furnace. Up to 34 per cent of the total charge weight has been actually used, although most pig irons require 20 to 30 per cent.

Lime and limestone—These are of normal open hearth composition. More attention is paid to the size of these slag-making materials. It is considered that maximum 2-in. size leads to more rapid slag formation. Uniformity in size allows even flow from storage hoppers and more efficient handling by conveyor belt line systems. The same standards for composition and texture apply to lime and limestone for the process as for open hearth materials but sizing must be smaller.

Iron Oxide—Iron oxide is added in limited amounts to assist in forming an early slag. The iron oxide used can be mill scale, iron ore, sinter or even dry L-D dust. It can also be used as a coolant to replace all the

scrap in which case it becomes a hot metal ore process. The replacement is made on a basis of one lb of ore for 3 to 3½ lb of scrap.

Carbon and alloy steels—One plant (Bochum Verein) is making nearly 100-per cent, hot-topped and bottom-poured steel. Heats are made by stopping the blow and catching the carbon.

In another plant (Gussstahlwerk Witten) 80 per cent of production is alloy steel. Up to 6-per cent alloy metals, including manganese, have been added without preheating.

Range of carbon steels made is 0.05 to 1.00 per cent in both these plants. Final phosphorus per cent is always 0.03 per cent maximum. Low phosphorus is attained by removing a first slag early and adding lime to make a new slag.

Oxygen consumption—Ore or scrap is used in the initial charge for cooling. In a 36-net ton charge, the following results were obtained:

Material	Per cent of charge	Blowing time	Oxygen consumption standard cu ft per ingot ton
Scrap	18.0	17.0	1570
Ore	6.0	15.3	1420

Under some conditions, ore may be favored economically over scrap because of: (1) lower cost per unit Fe; (2) saving in operating time; (3) saving in oxygen; (4) avoidance of unwanted residuals; (5) capable of being charged rapidly by the flux system.

Ore, as a source of oxygen, replaces gaseous oxygen and blowing time is shortened.

Slopping—Foaming of slag occurs in varying degrees during the major part of the blow. Toward the end, when the carbon evolution is decreasing, the foam normally subsides. If excessive foam still exists after turning down, corrective action by adjusting lance height is indicated for the next charge.

Slopping is the ejection of foaming iron-rich slag. It can develop rapidly; and when it does occur, it is usually early in the blow at a time which corresponds to the complete melting of the scrap.

Furnace dimensions and relationships between them and the size of charge have a major bearing on whether excessive slopping will occur or not. The volume above the bath should be enough to permit considerable foam formation within the vessel. Furnace design must allow for the specific materials to be used. If an unsuitable furnace has been installed, then operation to avoid slopping becomes a major problem.

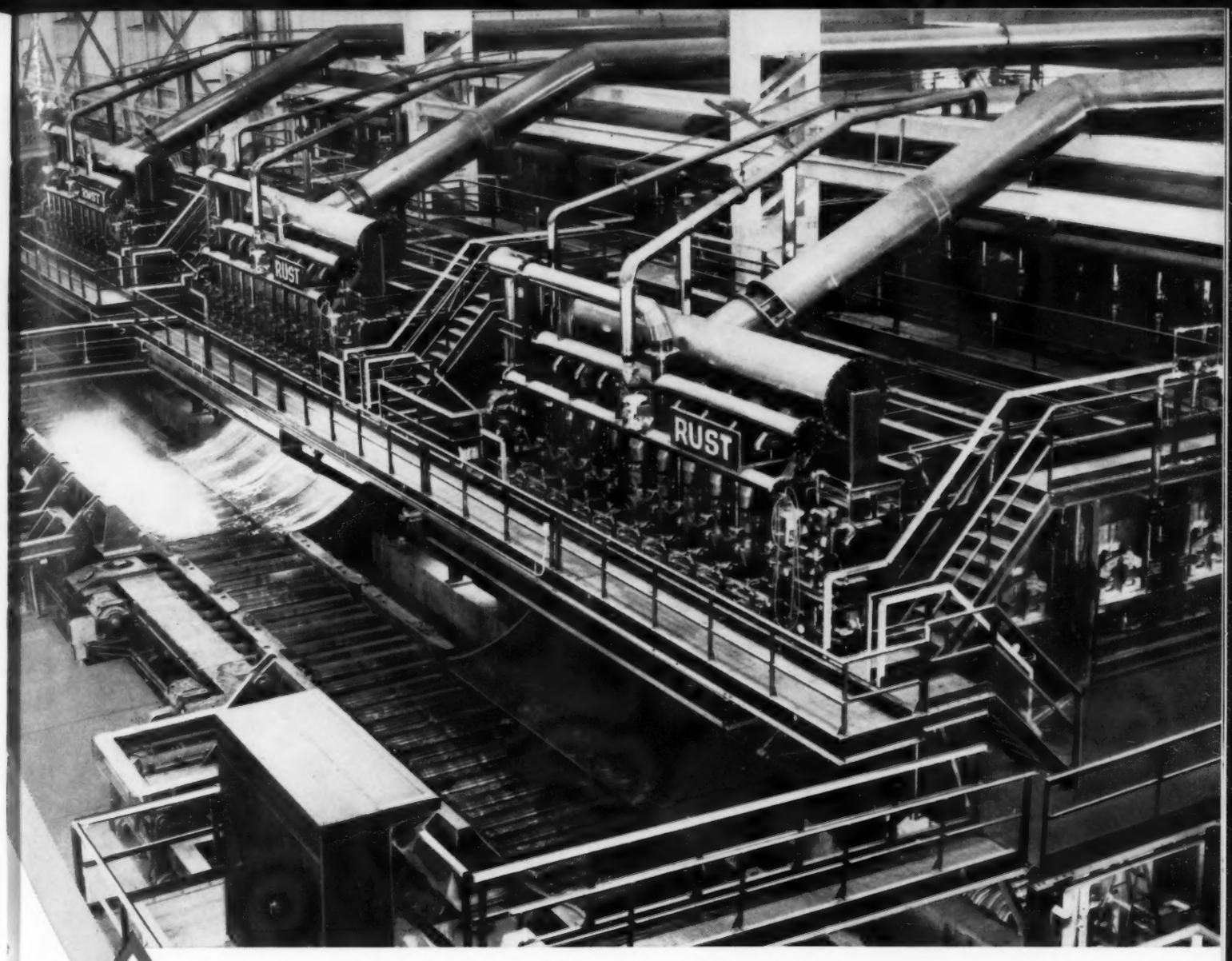
Nitrogen control—The usual nitrogen content of L-D steel is 0.003 per cent. The nitrogen content of the finished steel is a function of the purity of the oxygen. In one plant, when oxygen of 98.5-per cent purity was used, nitrogen in the steel was in the range of 0.004 to 0.006 per cent. On changing to oxygen of 99.5-per cent purity, the nitrogen decreased to 0.002 to 0.004 per cent.

Economic advantages of the L-D process—The capital cost for the construction of an L-D shop to produce around 1,000,000 tons of steel a year runs about $12 per annual ingot ton exclusive of the oxygen generating plant cost. This figure does not include stripping or mold preparation facilities. It depends on the type and design of equipment and on the restrictions imposed by the particular plant site. If it were decided to purchase outright an oxygen plant, the cost of the plant would be increased by about one-fourth to one-fifth. The total cost of the L-D plant will be about half of that for an open hearth plant producing the same quantity of steel annually. The wide variations in cost lie principally in building and in equipment. In view of the small size of the L-D furnace as compared to the open hearth, less building area is required. Capital charges for utilities, air pollution control and storage facilities are reasonably close for both open hearth and L-D plants of similar productive capacities. If either open hearth or electric furnace installations are to be replaced by L-D furnaces, there may be the wish to make use of existing facilities. Our experience when making studies for the conversion of existing shops to L-D operation indicates there is a break-even point so that almost as much money needs to be spent on the old plant to insure full productivity as would be spent for a new L-D plant. Capital cost may be less but this reduction is usually obtainable only at the expense of increased operating cost over a new plant. Most companies who are using this new process have built entirely new plants though, in one case, an old open hearth shop became obsolete.

Cost studies and estimations are theoretical to some degree unless based on individual plant practice. Therefore, it is most difficult to generalize. Studies show very similar materials cost-per-ton for both L-D and open hearth when using percentages of hot metal of the same order. So much depends on the relative cost per ton of hot metal, scrap and Fe in the ore, that definite costs are difficult to state, but a saving of somewhere in the neighborhood of $3 per ingot ton can be expected in large L-D plants over a modern open hearth plant of comparable capacity.

In figures for cost above per ton of steel, since the L-D furnace requires no external source of heat, one of the major savings is in fuel. The quantity of oxygen required is up to 0.08 ton per ingot ton. The cost of oxygen purchased under long term contract varies with the quantity bought. Oxygen cost-per-ton will show a saving on fuel cost in the open hearth. The cost of fluxes is higher for the L-D process because it is advantageous to use burnt lime instead of limestone. Furnace refractories and furnace repair are lower because of the simplicity of the furnace installation. Net refractory consumption is less than 20 lb per ingot ton compared with about 80 lb per ton for open hearth furnaces. Masonry labor is directly proportional to the quantity of refractory. Production labor costs are less than 50 per cent than those in an open hearth shop of similar tonnage.

In conclusion, for a particular plant modernization involving an increase in steel production, the economic importance of the process for making basic oxygen steel is so compelling that it *must* be given detailed study and evaluation. No using company, either in North America or in other parts of the world, has yet expressed any dissatisfaction with the process. Rather, the indications are in an opposite direction. ▲



RUST

Triple-Fired Continuous
Slab Reheating Furnaces

For KAISER STEEL CORP. 86″ Hot Strip Mill, Fontana, Calif.

THREE completely AUTOMATIC gas-fired RUST FURNACES, designed and constructed for Kaiser Steel Corporation's Fontana Works. Each furnace is designed to heat cold slabs to rolling temperatures at a rate of 150 tons per hour. Internal dimensions of furnaces: 24′ wide x 100′ long. Metallic recuperators minimize fuel consumption. This zone-fired type of Rust furnace is used by virtually all strip mills throughout the world. Consult us about your furnace requirements – melting, reheating or heat treating.

THE WHOLE JOB IS ONE JOB WITH A "RUST PACKAGE CONTRACT"

One contract covers everything from original idea through furnace start-up. One responsibility for design, manufacture, erection and initial operation. One overhead and profit (with substantial savings to you) on all phases of the work, including wiring and piping.

RUST FURNACE COMPANY

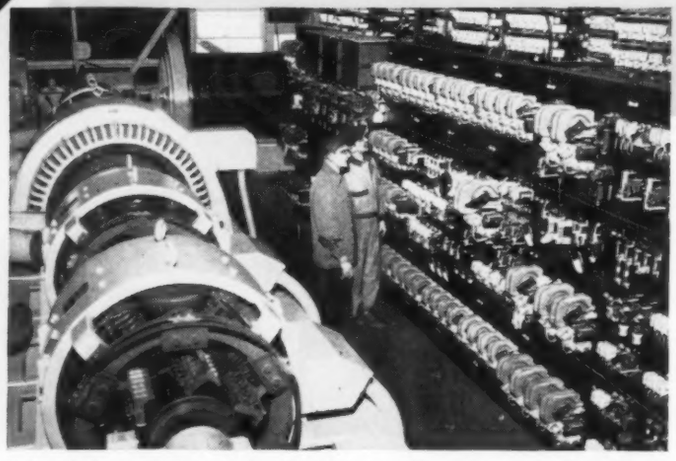
930 Fort Duquesne Boulevard, Pittsburgh 22, Pa.

Pioneers in Furnace Design

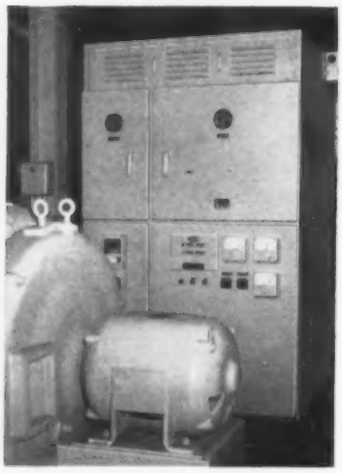
1800-TON-PER-HOUR DRAVO UNLOADER IN OPERATION AT PENNSYLVANIA RAILROAD'S GREENWICH POINT, PHILADELPHIA, ORE UNLOADING PIER

You're Under Way *Fast* WITH EC&M ADJUSTABLE VOLTAGE CONTROL!

EC&M Adjustable Voltage Control Panel *(mounted on trolley)* for Hold and Close Line Motors and for Trolley Motor, plus Protective Panel for other drives.



EC&M Control Panels for Hold Line, Close Line, Trolley, Turntable, Quadruplex Travel, Rail Clamps and Apron Hoist Motors are mounted in Machinery room, 100 feet above ground level, along with generators which supply DC power for unloader motors. Power resistors, mounted above Panels, are EC&M TAB-WELD.



EC&M Type ZHA 4160 Volt Starter provides pushbutton starting of 800 HP Elliott synchronous motor driving 4 generators.

This Dravo Unloader is typical of many prominent installations on which EC&M has worked with both unloader and motor builders to get machines into production quickly with minimum adjustment and "tune-up" time.

Equipped with a total of 20 motors ranging in size from 10 to 800 HP, this unloader takes giant-sized bites (22½ tons) of ore from a ship's hold on an average cycle handling time of 45 seconds. Frequently, the skilled operators lower the time to 36 seconds per trip.

The bucket (hold and close line motors) and trolley drive are operated by adjustable voltage control under current limit acceleration through rotating regulators. Constant potential control is used for the travel, rail clamps, turntable and apron hoist.

EC&M is prepared to supply complete equipment including control, brakes, limit stops and all rotating machinery. When planning adjustable voltage installations, consult EC&M for engineering assistance.

Photos courtesy Dravo Corporation, Elliott Company and the Pennsylvania Railroad

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

9104

Femco Accelerates Activity In Telemetering And Remote Control

FEMCO, Inc., a company born in a backyard garage, celebrates its 20th anniversary this year with a sales goal of over $1,500,000. Two electrical engineers started the firm in 1939 as a spare-time venture. Six years later, the company grew to a full-time operation.

Today, Femco designs, develops and manufactures equipment for the transmission of information by voice or signals, such as:

1. *Communications*—carrier and wired audio systems for all mining and industrial applications.

2. *Monitoring*—fans, circuit breakers, valves, pumps and compressors.

3. *Telemetering*—flows, levels and pressures.

4. *Remote Controls*—pumps, compressors, valves, circuit breakers, soaking pit covers, furnace doors, cranes and other moving equipment.

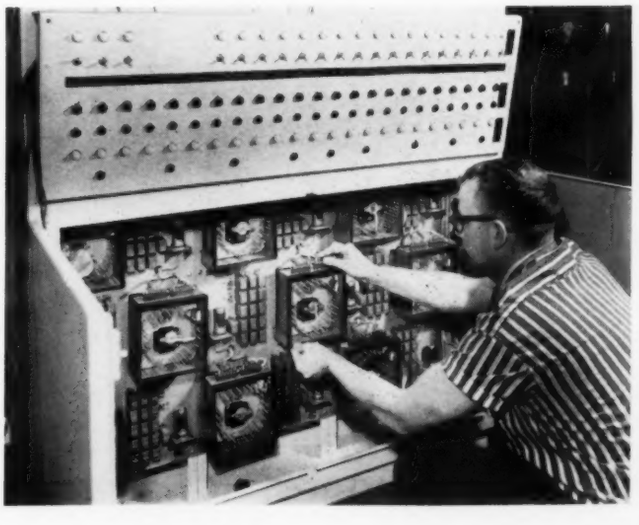
W. P. Place and N. F. Agnew, the founders, foresee new industrial markets, increased sales and greater expansion in future years. Sales passed the million dollar mark in 1956 and continue to climb each year. Employees number over 100. Factory facilities are now housed in a modern white brick building on seven acres of land near Irwin, Pa.

Sales offices have been established in 11 major U. S. cities, with sales representatives in Canada, and manufacturing licensees in Paris and London. Equipment has been sold in South Africa, Japan, South America, India and practically all European countries.

The company was first called the Farmers' Engineering and Manufacturing Co. after its first product—an electronically-operated charger for farm fences. For five years this continued to be the firm's major product. But then the partners began paying increased attention to the development of communications. Farm devices were gradually eliminated.

Figure 1 — This craneman merely has to flip a switch to activate the automatic Femco relay controls that open and close 15 soaking pit covers at the U. S. Steel Corp. mill in Homestead, Pa. Switches are provided so the crane operator can select a pit position and cause the ingot buggy to stop automatically on its return from the dump position, or the operator may control the buggy in either direction by another control lever.

Figure 2 — This monitor control console is given a final in-plant inspection before shipment to the U. S. Steel Corp. coke manufacturing plant in Clairton, Pa. This console, featuring nine circuit scanners, will be used in conjunction with telemetering and audio tone equipment to control and indicate the flow of gas in the coke ovens. The tester is adjusting one of the scanners, the heart of these control systems.



In 1945, Mr. Place and Mr. Agnew, who by then decided to devote their full time to their offspring, designed the first of the present line of products, the trolleyphone, a frequency-modulated carrier system primarily for mines and which uses power lines for voice communication between fixed stations and moving equipment. This is the product that helped Femco grow.

The trolleyphone itself was the first wholly successful system for underground communication in mines. Hundreds of mining and industrial installations have been made since then in this country and abroad.

This new character of the business made the original company name misleading. In 1954, when the firm incorporated, the name was shortened to Femco.

The trolleyphone principle was used in the development of the Femco cagephone, voice communication between fixed stations and mine cages, and the Femco cranephone, communication between floor points and traveling cranes. Femco has also designed a variety of telephone systems for mining and industrial use between fixed points. These include virtually any type of service desired—loudspeaking, paging, private conversations and group conferences. Communication products provide a major portion of Femco sales volume.

However, in recent years, Femco has been expanding its research and engineering effort to the field of telemetering and remote control, an area in which the company anticipates its most rapid growth. Actually, it was a short step from the transmission and receiving of a *voice* signal to the transmission and receiving of an *indication* or *control* signal. Femco engineers have developed systems for remote control of various types of equipment, including monitoring and telemetering—employed independently or in connection with remote control. At present, all Femco systems are wired, using existing power lines or leased telephone lines. In the applications with which Femco has been chiefly concerned, wired systems have been preferable to radio because they have been more economical to install and easier to maintain. Some of the steel mill applications for Femco equipment are the remote control of soaking pit covers from the soaking pit overhead crane cab; control and indication of gas flow in coke ovens, remote control of overhead cranes, unloaders, ingot buggies and transfer cars; signalling of blast furnace wind requirements from the blowing room and the return of an answer; plus blast furnace temperature and pressure monitoring.

While the majority of Femco sales have been in the coal and steel industries, the company through its development in the controls field is now rapidly expanding into other fields such as the oil and gas, railroad and water industries.

The idea of transmitting information from point to point and the need to telemeter, monitor or remotely operate various functions is common in each. With Femco's existing products and marketing organization, it is in these fields that the firm aims for its future growth. ▲

SUPERIOR
CARBON
BRICK
FOR

◀ Blast furnace linings
◀ Blast furnace run-out troughs
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Standard sizes and shapes • Tested performances
Competent technical service • Superior chemical and metallurgical characteristics • Graphite brick also available.

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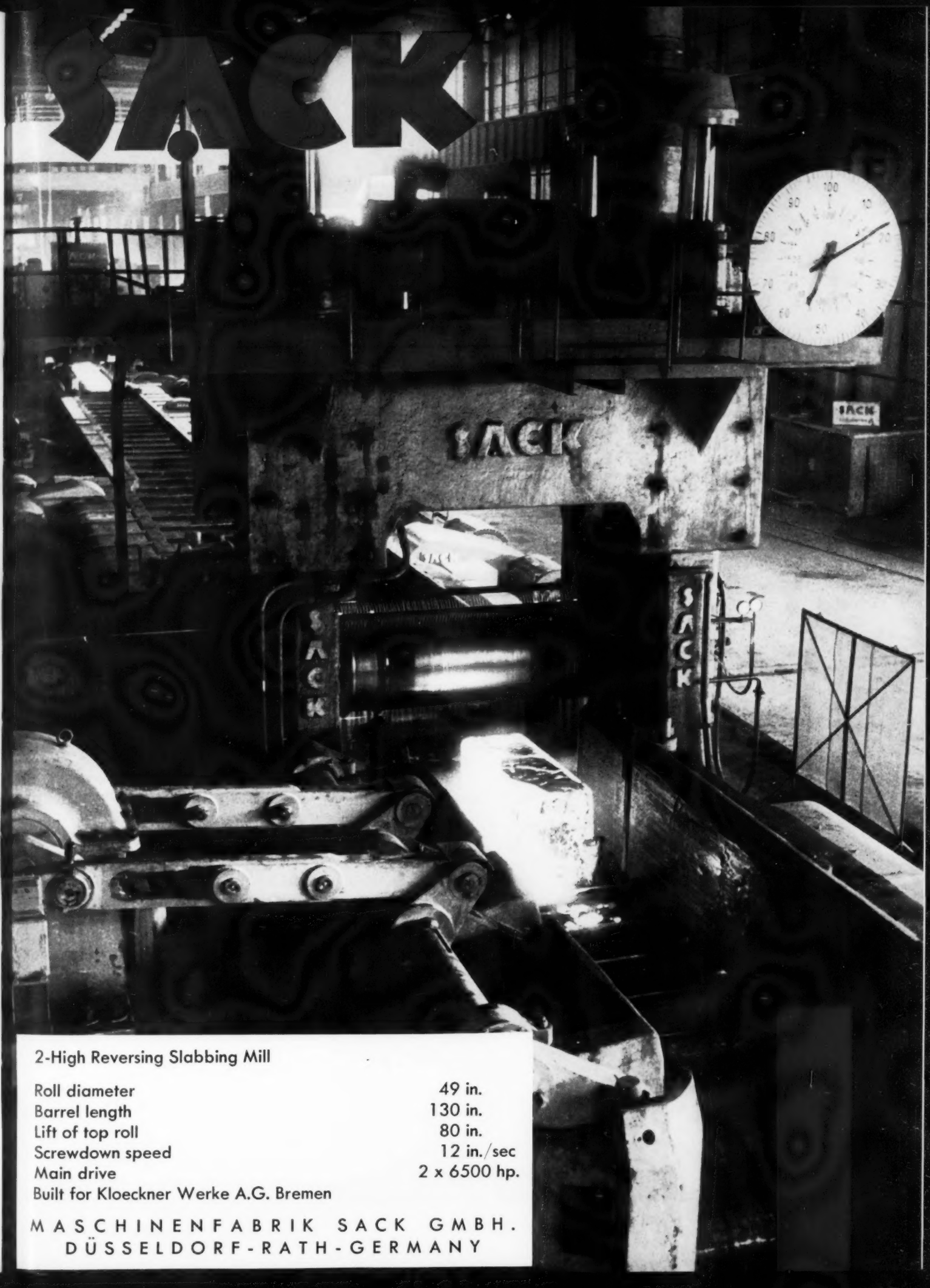

2-High Reversing Slabbing Mill

Roll diameter	49 in.
Barrel length	130 in.
Lift of top roll	80 in.
Screwdown speed	12 in./sec
Main drive	2 x 6500 hp.

Built for Kloeckner Werke A.G. Bremen

MASCHINENFABRIK SACK GMBH.
DÜSSELDORF-RATH-GERMANY

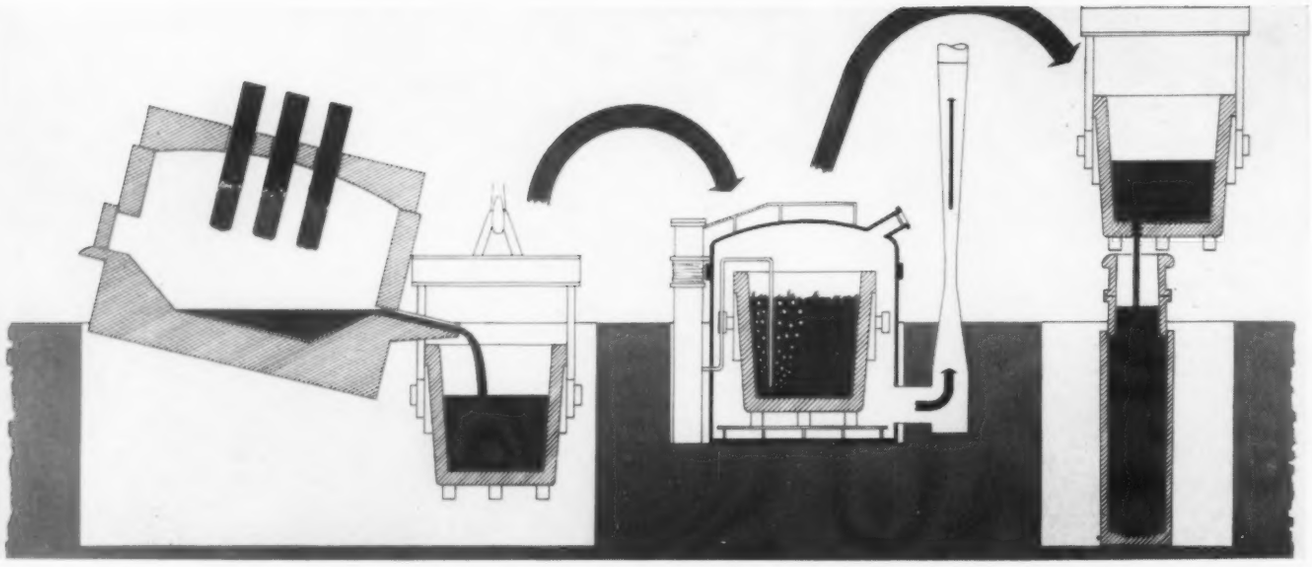

Figure 1 — Flow chart depicts the Finkl vacuum degassing process. The heat is tapped into the ladle which is transferred to a degassing chamber and then teemed conventionally.

Finkl & Sons Develop Process to Degass Steel in the Ladle

A VACUUM degassing process which "cleanses" steel in the ladle, is operating on a production basis at A. Finkl & Sons Co., Chicago manufacturer of die blocks, forgings and heavy machined parts.

Figure 2 — The vacuum chamber, with the ladle inside, is checked during the degassing operation. Automatic control panel in the background regulates the steam suction pumps which create the vacuum.

In the process, which was developed by the Finkl Co., 3000 F nickel alloy steel in 75,000 lb heats is tapped from an electric furnace into a ladle. The ladle is then moved into a vacuum chamber where the degassing operation takes place.

Four steam ejector suction pumps instigate a high vacuum in the chamber, causing hydrogen, oxygen and nitrogen gas to boil out. To increase the purifying action, helium gas is injected into the molten mass for mixing.

After degassing, the steel is teemed into one or more ingot molds in the conventional manner. According to company tests, the degassing process reduces the hydrogen content from approximately 3.9 to 1.5 ppm.

The degassing cycle in the ladle takes about 12 minutes, and the temperature loss is slight; production records indicate that steel is poured into ingot molds at approximately 2850 F. In this connection, the company has found that vacuum degassed steel can be poured some 30 degrees lower than non-degassed steel.

The Finkl company developed the process in preference to conventional degassing systems because of the flexibility of pouring which the process affords. With conventional degassing systems only one ingot can normally be poured.

About 80 per cent of Finkl's special purpose steel is being vacuum degassed. ▲

Contamination wreaks havoc on film!

One NATIONAL TRADE-MARK brush grade conquered Contamination—Humidity—Low Loads!

MORGAN HENIKA

"Commutator trouble was a big expense item in this eastern pulp and paper plant," says "National" Carbon Brush Man, Morgan Henika. "And no wonder," continues Morgan, "paper machine drives worked on low loads in a highly humid, contaminated atmosphere!"

Morgan recommended "National" Brush Grade HRG. The results were outstanding—trouble-free performance and big maintenance savings. Today this brush grade is used on almost all drives in the mill.

Don't give up on *your* brush problem until you call your "National" Carbon Brush Man. His experience—*backed by "National's" long term brush research*—may be just the help you need. Call your local office or write to National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

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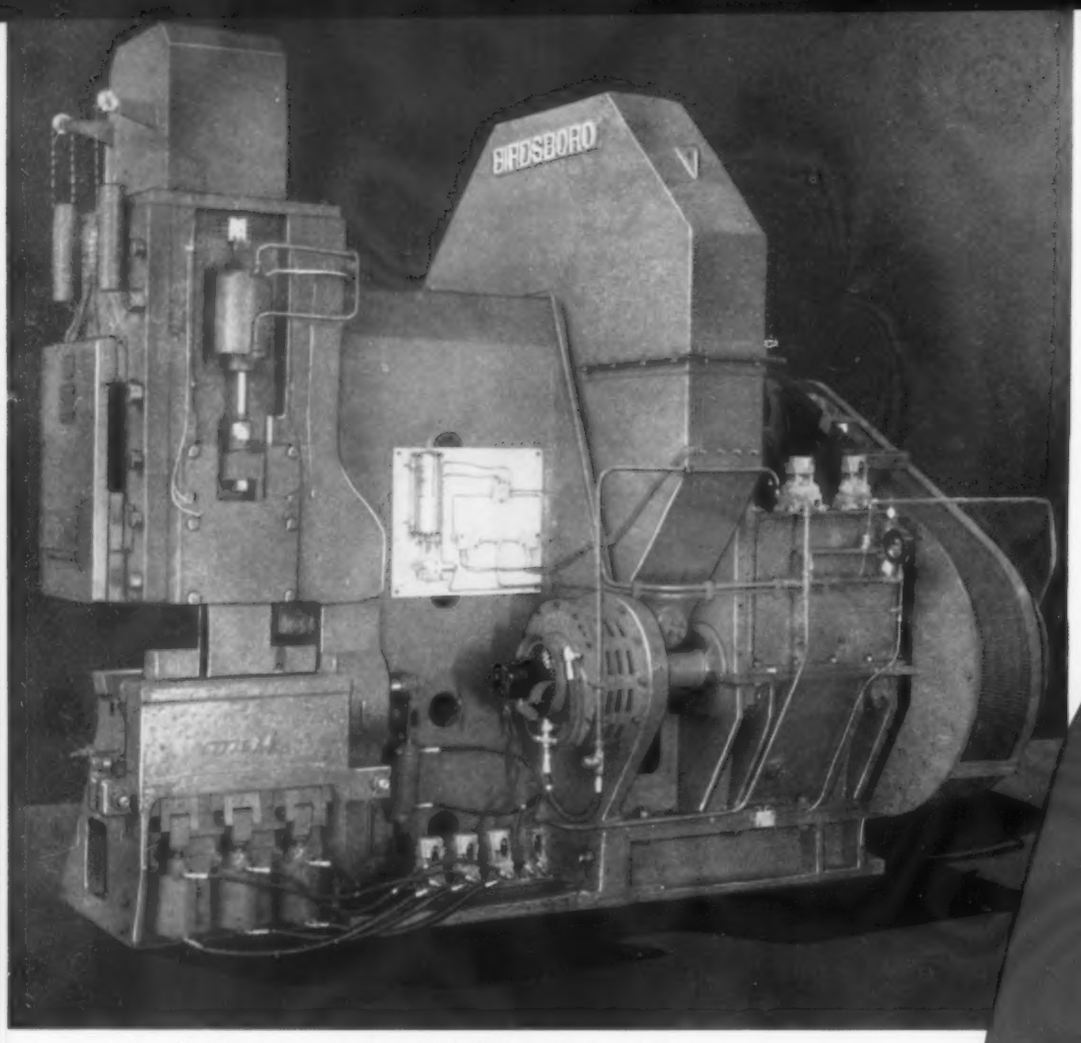


500-ton Birdsboro Down-cut Shear with Wichita Clutch and Brake

"Wichita Clutches IMPROVE DESIGN and performance"

says
E. C. Peterson, Vice President
Rolling Mill Equipment Division
BIRDSBORO STEEL FOUNDRY
AND MACHINE COMPANY

"Wichita Clutches have been used five or six years on many of our clutch applications," says Mr. Peterson, "and we have experienced definite advantages over clutches formerly used. This has been an important factor in improving the design and performance of Birdsboro Shears."

Tough clutching and braking applications on many types of machines have demonstrated again and again the outstanding advantages of Wichita performance. Be sure you are getting the best equipment there is . . . check with the Wichita Clutch and Brake Specialist nearest you.

Wichita Low Inertia Air-Set Disc Brake

Wichita Low Inertia Air-Tube Disc Clutch

Contact your nearest Wichita Engineer!

Clutch & Control Engineering Co., Livonia, Mich.
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
Norman Rupp Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

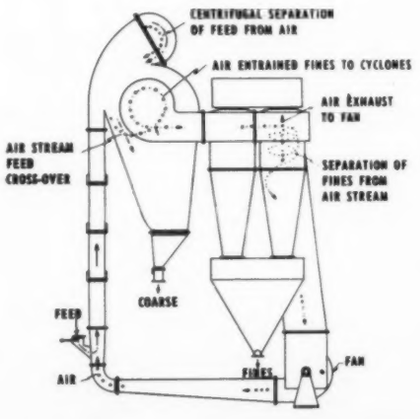
WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U. S. A.

HIGH-EFFICIENCY CLASSIFIERS Help Beneficiate Iron Ore

NEW high-efficiency classifiers recently introduced by the Buell Engineering Co., 123 William Street, New York, N. Y., have found application in the metals field in the beneficiation of iron ore and the preparation of limestone for sintering. The new classifiers separate dry fines from coarse materials at efficiencies hitherto unattainable in commercial practice. They have no moving parts, require virtually no maintenance and utilize but 0.04 to 0.5 hp per ton per hr.

The Buell classifiers make use of aerodynamic forces in combinations not previously used in the classification field. They are available in three types—the centrifugal classifier, recommended for applications in the 400 to 200-mesh range; the gravitational-inertial classifier, for use in the 200 to 50-mesh range; and the gravitational classifier for use in the 50 to 10-mesh range.

Figure 1 — The centrifugal classifier separates materials in the 400 to 200-mesh range.



CENTRIFUGAL CLASSIFIER

As shown in Figure 1, feed material and gas, usually air, enter the centrifugal classifier through a sharp bend at the top, and air and feed are separated by centrifugal force, the air stream passing behind a baffle plate against which the feed material slides. The air stream then crosses the curtain of feed material resulting in an intense scrubbing action separating fine particles from tailings, breaking up agglomerates and subjecting all particles to an equal drag force. Very large particles, if present, are immediately precipitated by gravity to the bottom of the classifier. Intermediate and finer particles flow with the gas stream in a spiral path around the exhaust orifice.

Each particle is acted upon by centrifugal and drag forces. Centrifugal force tends to move the particles toward the periphery of the chamber and is opposed by the drag force. Under set conditions, the centrifugal force will equal the drag force for particles of a particular diameter. This diameter is referred to as the "cut point." Particles of larger diameter are propelled outward to the peripherial walls of the classifying chamber against which they impinge and fall by gravity to the bottom of the chamber. Particles of smaller diameter are swept inwardly and discharged with the gas stream through the outlet orifice to a Buell cyclone.

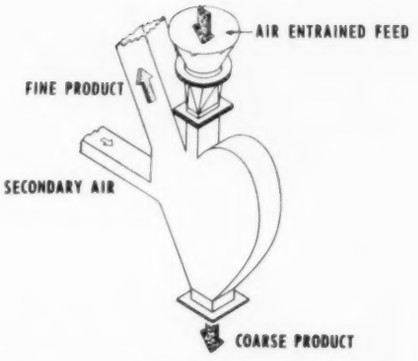


Figure 2 — The gravitational-inertial classifier is used in applications where the material falls in the 200 to 50-mesh range.

GRAVITATIONAL-INERTIAL CLASSIFIER

Air or gas entrained feed material enters the gravitational-inertial classifier (Figure 2) through an inlet at the top, and cascades downward past a set of inclined vanes through which air and entrained fines are drawn off. By controlling the veloci-

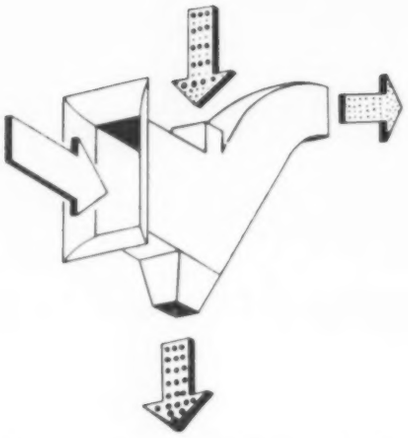


Figure 3 — The gravitational classifier is used for the coarser materials in the 50 to 10 range.

ties of the inlet air and vane exhaust air, gravitational, inertial, centrifugal and drag forces are caused to act on the particles in such a manner that those below a given size will be drawn off through the vanes and those above this size will continue to precipitate downwards.

A secondary air supply introduced below the vanes crosses the stream of coarse particles, scrubs away any adhered fines, and circulates into the classifier chamber, exhausting through the vanes. It provides a means of controlling inlet air velocity and also acts along with primary-air eddy currents as a moving wall which contains the curtain of feed material within the classification zone without the detrimental frictional drag forces of a fixed wall.

By regulating secondary air flow and maintaining constant exhaust air velocity, the primary inlet velocity is regulated and the various aerodynamic forces are controlled to separate fines smaller than a given diameter.

GRAVITATIONAL CLASSIFIER

Feed material enters the gravitational classifier (Figure 3) at the top and low velocity air is blown through it at right angles as it cascades downward. The air stream then turns sharply upward and passes between widely spaced vanes as it enters the outlet duct. In so doing, particles smaller than a given size are carried through the outlet and particles larger than this size impinge on the vanes and are thrown back into the feed curtain, or, if large enough, simply continue straight downward unaffected by the air stream. The cut point is controlled by regulating the air velocity. This varies the magnitude of the drag and centrifugal forces and will alter the resultant aerodynamic force on each particle. By properly regulating this force, particles smaller than a selected size will be collected with the fines while larger particles will be collected with the coarse. A very small percentage of particles having the exact size as the cut point designation may be collected with either the fines or the coarse.

In addition to their application in ore beneficiation and limestone classification, the new classifiers may be used in classifying metal powders, sintered metals, mineral flowers, milled products, fillers, fibers, fertilizers, chemicals, food powders, resin powders, fluid catalysts, salts and crystals, pulverized coal, soap particles and cosmetics. Figures 4 and 5 show typical centrifugal and gravitational-inertial classifier installations, respectively. ▲

Figure 4 — This is a typical centrifugal classifier installation.

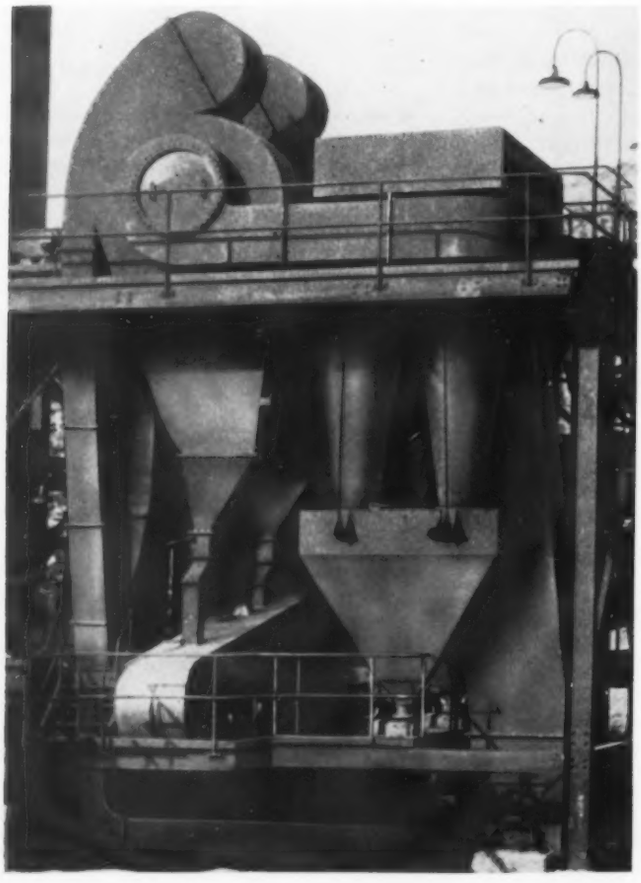
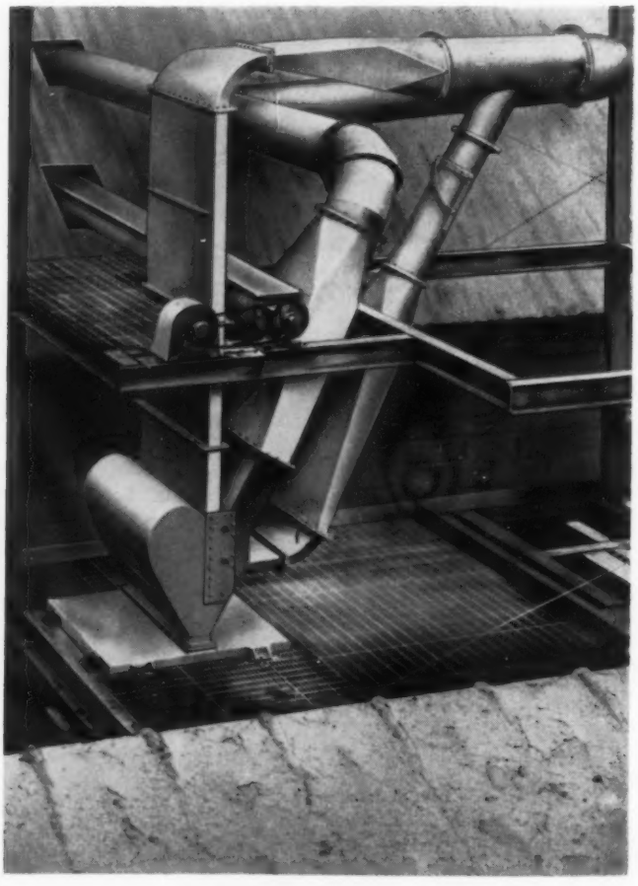
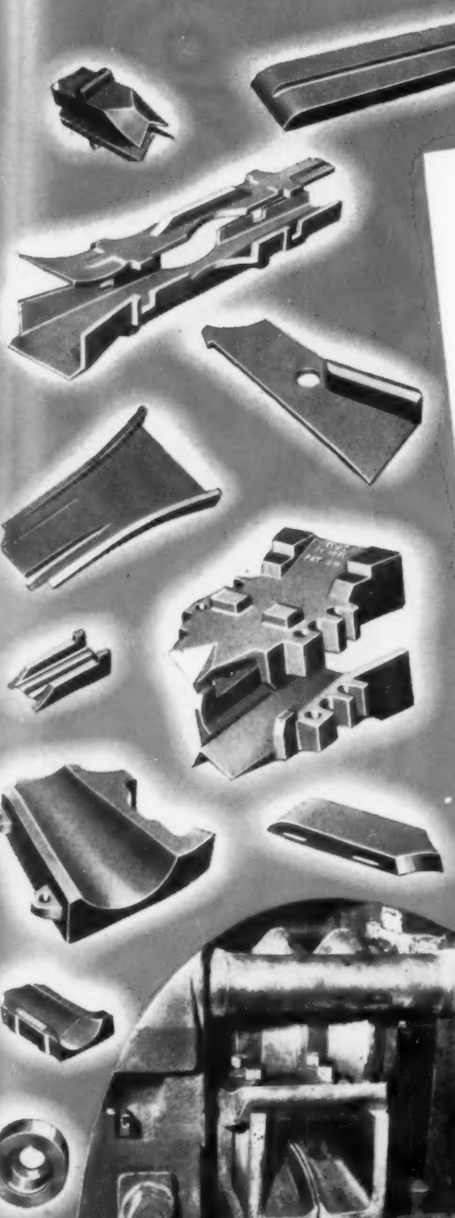


Figure 5 — Shown here is a gravitational-inertial classifier installation.



TRANTINYL GUIDES
THE STEEL INDUSTRY



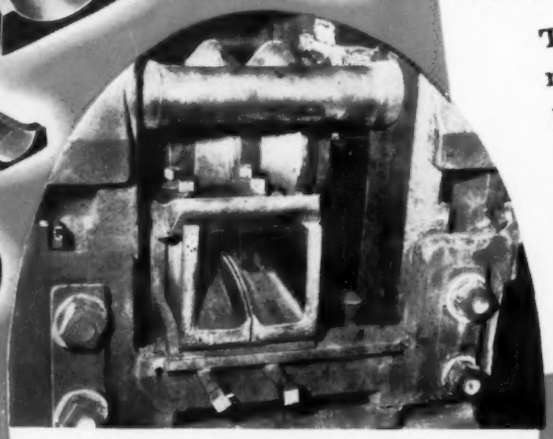
Steel Producers amazed at HIGH TONNAGE rolled with TRANTINYL GUIDES

Entry Guides

Delivery Guides

Two pair of angle guides, still in serviceable condition after long usage

These entry and delivery guides on 12" mill were photographed in a midwest steel plant after rolling unusually high tonnage. Guides showed no noticeable signs of wear and proved again the outstanding durability of "TRANTINYL." If you have not yet tested "Trantinyl" guides to your own satisfaction, why not try them now.



12" Mill showing Entry Guides

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century. Rolling more than 100,000 tons over a single pair of guides has been recorded.

Guides for Rolling Mills • Tube Mills
Straightening Machine Guides
Heat-Resisting "Trantinyl" Cast-to-Shape

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"TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

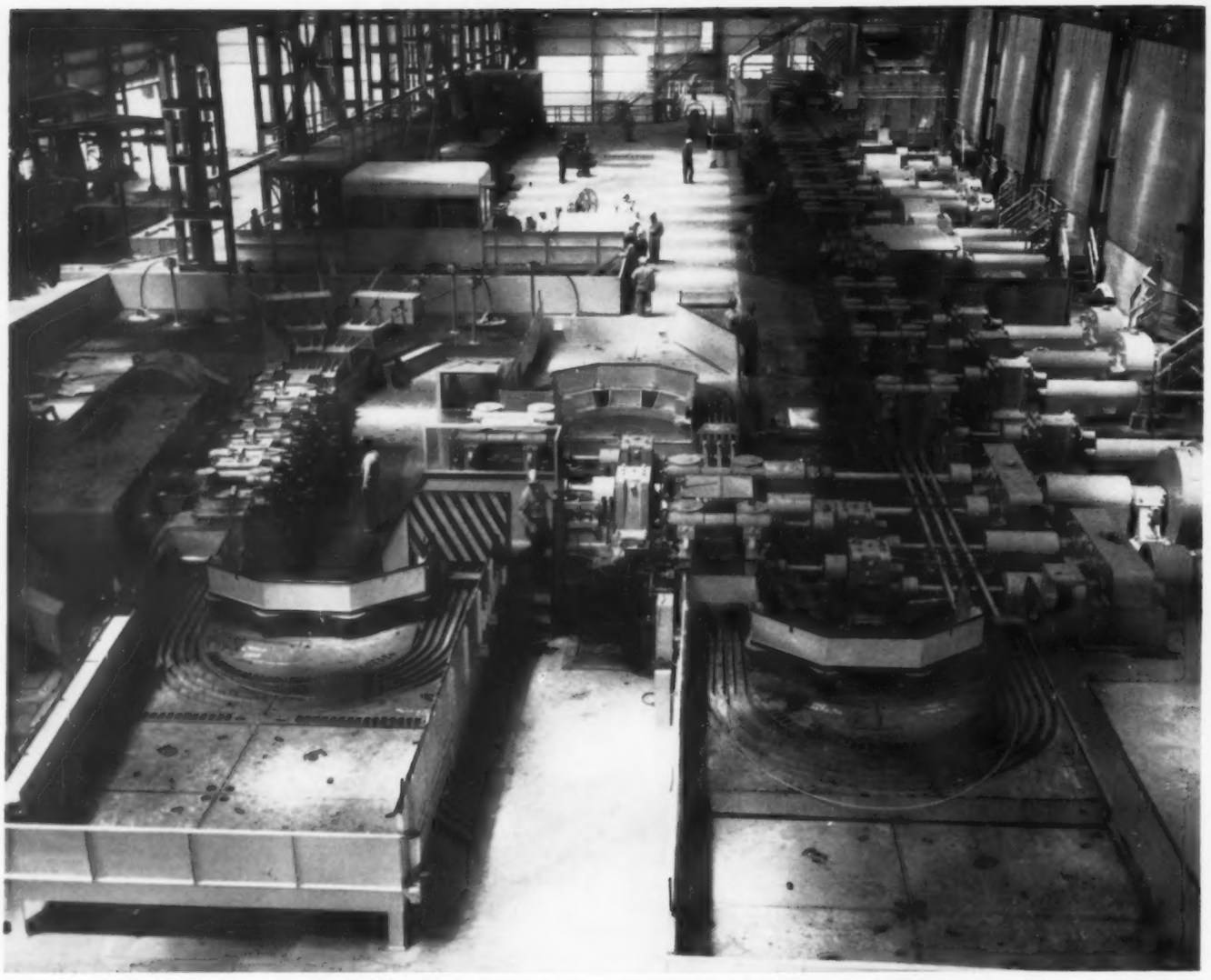

Figure 1—Built at a cost of $10,000,000, the 23-stand, 3-strand mill is believed the fastest 10-in. rod mill in the world. Billets leave the billet reheating furnace in the upper left of the picture and travel through the roughing mill, intermediate mill, looping mill with its three repeaters, and into the 6-stand rod finishing train. From there they pass through the high pressure water descaler and are coiled on laying reels.

New Rod Mill Starts Operation at Kansas City

A NEW rod mill started operation on June 15 at the Kansas City plant of Sheffield Div., Armco Steel Corp. The 23-stand, three-strand mill is believed to be the fastest 10-in. rod mill in the world. Built at a cost of approximately $10,000,000, the mill is the most expensive single project in the history of the Kansas City works. Planning and construction of the mill took five years.

Purpose of the new mill is to produce competitively priced, high quality finished rods for reinforcing and wire rope, and increase production of wire mill and bolt and forged products. Preliminary estimates indicate the new mill will more than triple present rod production at the plant.

The most modern concepts of rod mill design have been incorporated into the new mill. The mill's production cycle begins with 1000 to 1800-lb, 40-ft long, $2\frac{3}{4}$ to $3\frac{5}{8}$-in. square steel billets. These billets are reheated to 2100 F rolling

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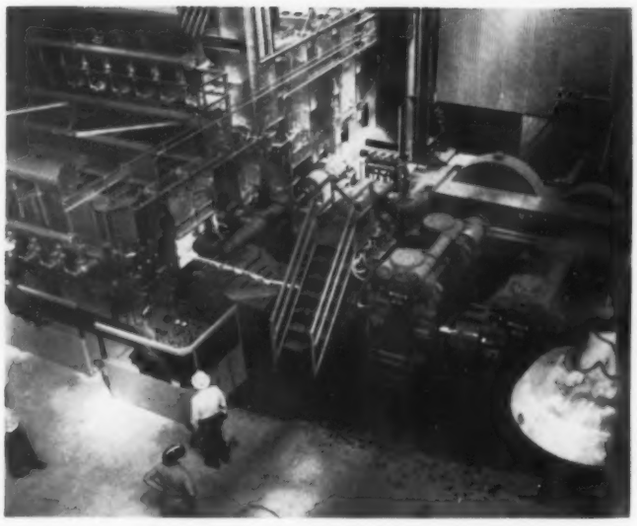


Figure 2—The first billet is pushed out of the 2-zone billet reheating furnace into the roughing mill. Though the mill will not reach rated capacity for some time, by the third day of operation, the crew had the mill rolling and coiling No. 5 rod in all three strands simultaneously.

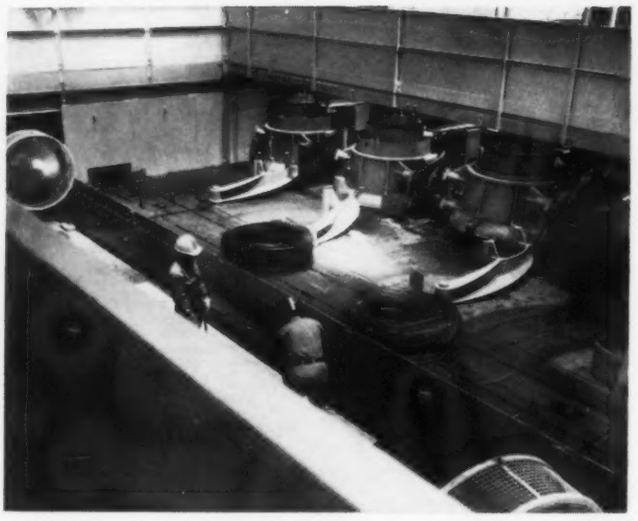


Figure 3—These laying reels coil rod at speeds up to 6500 fpm. Each coil weighs 1000 lb, making Sheffield's Kansas City plant the second steel mill in the country to coil continuous rod coils of that weight.

temperature in the billet reheating furnace. From the furnace, billets are pushed into a three-strand switching mechanism and begin their journey through the 23-stand, closed-top housing, Morgoil-bearing-equipped mill. The rod mill is made up of four multi-stand mills: the roughing mill, intermediate mill, looping mill with its three repeaters and six-stand rod finishing train.

From the finishing train, rods pass through a four-stage, high pressure water descaler to insure high quality. Then traveling at speeds up to 6500 fpm, the rods are delivered into reels. The reels coil 1000 to 1800 lb of rod, making Sheffield's Kansas City plant the second steel mill in the country to coil continuous rods of that weight.

Roller twist guides, designed for the mill by Morgan Construction Co., make the high speed possible. Installed for the first time at Kansas City, these guides are set at a 45-degree angle and automatically twist rods after they pass through stands 1, 3 and 5 in the rod finishing train. The roller twist units also hold scratching of rods to a minimum. If the guides meet expectations, rolling speed—which has been the major limitation of high yield rod production—will be greatly increased in mills of the future.

Other features of the mill include: the latest continuous circulating lubrication systems which require five viscosities of oil; a signal control panel which automatically locates points of trouble in the lubrication systems; two hydraulic systems for traverse alinement and top roll balance; double-deck construction which gives the mill a yard level and an elevated deck 14 feet above the ground for the mill; magnetic amplifier speed regulating equipment which will control the speed of the mill's 23 stands to within $\frac{1}{4}$ of one per cent; a narrow gage railroad which will transport crop ends from beneath the mill to a scrap car, and a Rust two-zone billet reheating furnace—43 x 50 ft—which has a rating of 112 tons an hour.

Perhaps the most interesting feature of the mill is the way Sheffield engineers have solved a problem of geography. The new rod mill is located on the east side of the Blue River. Spanning the 1750 ft distance from the new rod mill to the wire mill on the west side of the Blue River is a covered, overhead hook carrier, for delivering coiled rods to the wire mill. The carrier will also deliver coils to an unloading station in the rod mill for shipment to other fabricators. The carrier crosses the river, several railroad tracks and a heavily traveled road.

One of the major problems of all rod mills—the cobble—will be minimized in the new mill. If a rod fails to complete its journey through the finishing stands, photcelectric equipment will start automatic operation of the crop and cobble shears. The shears will begin chopping the cobbled rod into short lengths for easy handling. The shearing operation can be started by an operator on the mill before the bar reaches photoelectric signaling devices. Cold ends of bars are also automatically cropped after the bars pass through the intermediate mill.

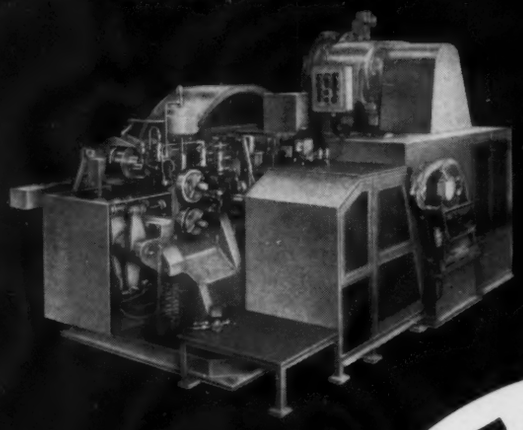
At present, the mill will coil rods from 0.218 to $\frac{7}{16}$ in. in diameter. Pouring reels which will be installed this year, will enable the mill to coil from $\frac{7}{16}$ to $1\frac{3}{8}$-in. rods.

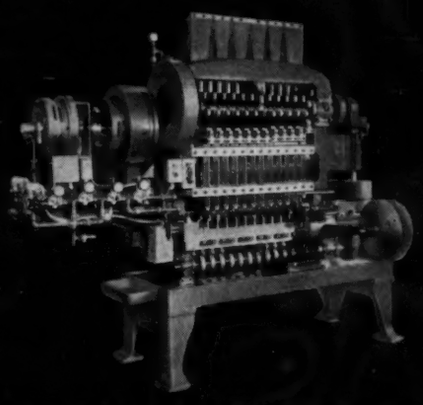
Main drives of the mill total 11,500 hp. However, not all of this power will be utilized at the present time. The mill has been designed to roll skelp and merchant bars and shapes. The reserve power will be needed in the future when facilities are expanded to include these products.

Every safety precaution known has been taken to protect the mill crew. All moving parts possible have been guarded. Screens have been placed over mill housings to confine cobbled rods. The furnaces have been equipped with automatic cut-off valves.

Morgan Construction Co., Worcester, Mass., is the designer and builder of the mill. Westinghouse Electric Corp. supplied the mill electrical equipment. The general contractor is Rust Engineering Co., Pittsburgh, Pa. ▲

COLD HEADING
MACHINERY





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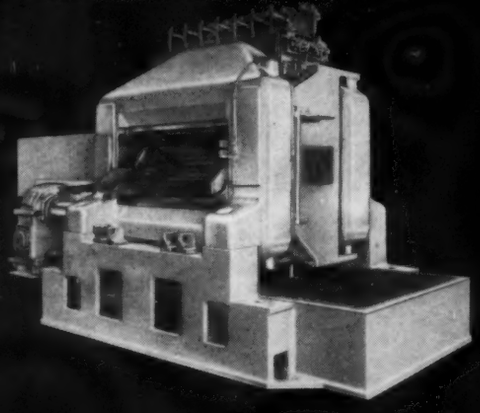

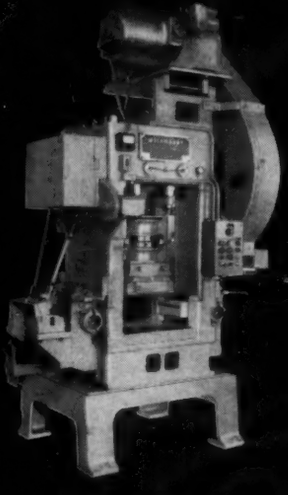

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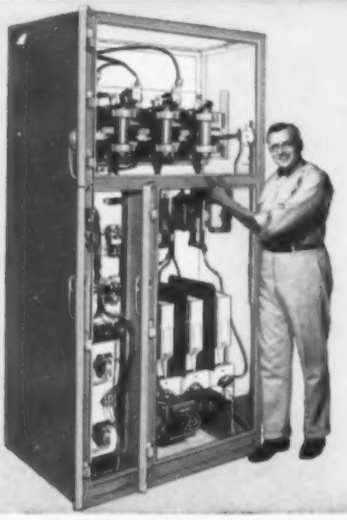

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New Dravo Man-Trolley Ore Unloader Handles 1,650 Gross Tons an Hour at Interlake Iron

A new Dravo boat unloader is removing ore from Great Lakes vessels at a peak rate of 1,650 gross tons an hour at Interlake Iron Corporation's Chicago Plant.

It is a part of a major dock and ore yard expansion program, and was built by Dravo under contract from Arthur G. McKee & Company. One feature of this new unloader is a ring-type turntable on the man-trolley. It facilitates hold clean-up by permitting 90-degree rotation of the bucket in either direction.

Dravo six-foot stroke, hydraulic buffers, located at either end of the man-trolley tracks, insure safe trolley stops in case of accidental over-run. Further protection is furnished by Dravo *Gale-Guard* rail clamps which automatically hold the structure to the rails whenever wind velocity exceeds 35 mph or when power is shut off.

Other specifications on this unloader include: Unloader Height: 100 feet. Man-trolley Speed: 960 feet per minute. Tower Speed: 115 feet per minute. Bucket Size: 300 cubic feet (18 gross tons).

Find out how Dravo's experience in ore and coal handling equipment can serve you. Write, wire, or telephone: Materials Handling Department, Dravo Corporation, Pittsburgh 25, Pennsylvania.

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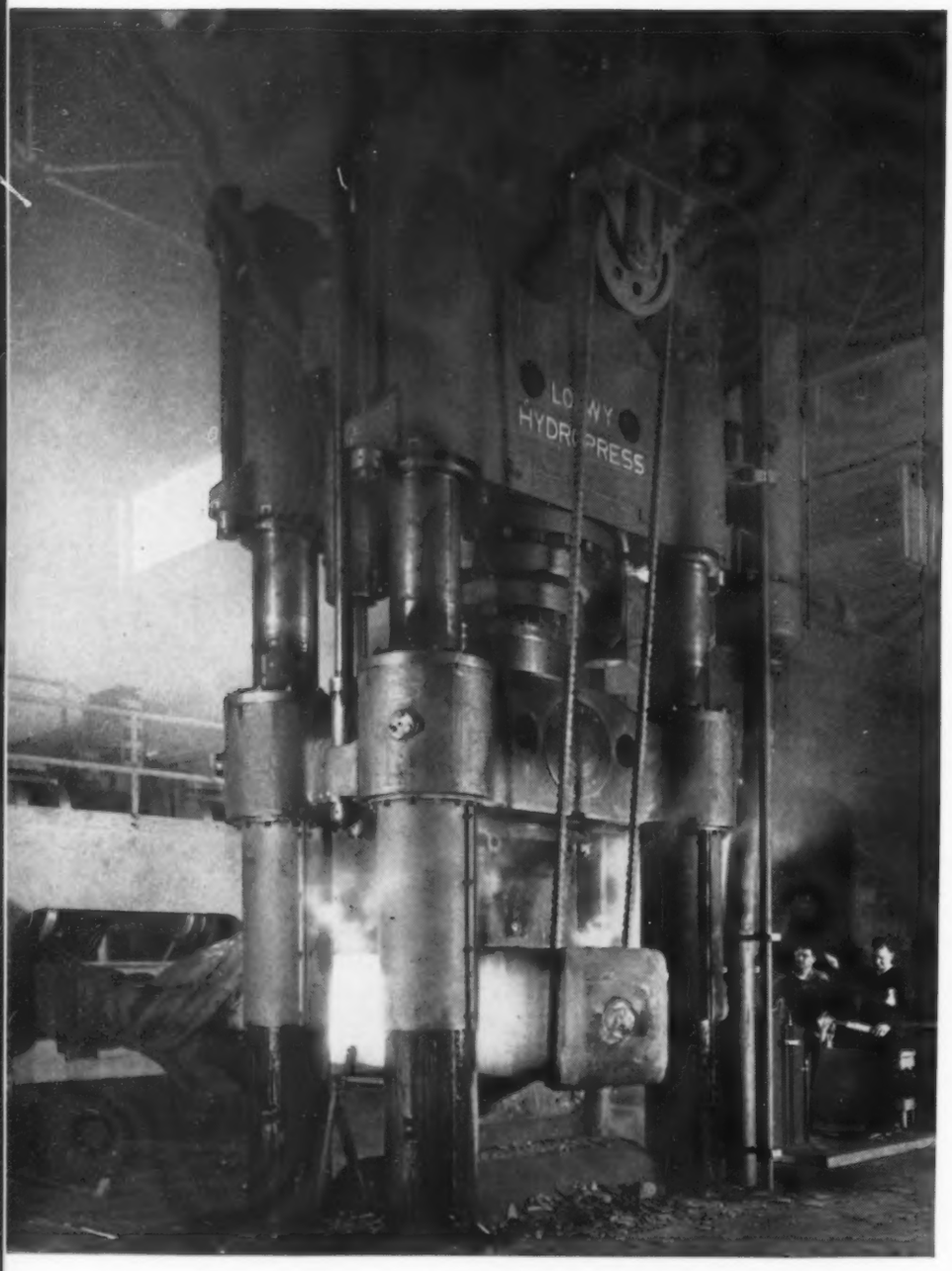
From Loewy presses... high-quality steel forgings faster and bigger!



Loewy 2000-ton fast-forging press at Colonial Steel Co., a division of Vanadium-Alloys Steel Co.

Vanadium-Alloys Steel Company, a leading producer of tool and special steels, recently announced the completion of a $3,500,000 expansion program, including a powerful Loewy 2000-ton-capacity forging press now in operation at Vanadium's Colonial Steel Co. Division, in Monaca, Pa.

"The use of this press," according to the customer, "will greatly speed up deliveries of forgings and at the same time offer a more uniform product with better quality control."

Due to its large daylight and die bed dimensions, the press will handle ingots measuring from 12 to 40 inches square and weighing from 1 to 10 tons. A wide range of materials, such as bearing steels, ultra-high-strength missile and aircraft steels and high-temperature alloys will be used in the forging operations to produce an extensive variety of products.

Leading alloy-steel makers praise Loewy fast-forging presses for their trouble-free operation and for the fact that they impart to special steels "internal qualities never before achieved." Equally important, they consistently outproduce conventional hammers and blooming mills.

Loewy forging presses are designed for full accessibility of tooling, easy supervision and maintenance. Fast closing, working and return speeds cut down idle time and prevent heat loss in the workpiece. Strokes per minute for planishing are unsurpassed by any other type of forging equipment. Pressure, tonnage and speed can be varied within a wide range to suit special requirements.

Loewy-Hydropress designs and builds open and closed die forging presses ranging from the smallest sizes to the enormous capacity of 50,000 tons. For further information, write Dept. C-9.

Loewy-Hydropress Division

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Date-line Diary...

August 3

Δ The AISI reports that the operating rate of the steel industry for the week of August 3 is scheduled at 332,000 tons (11.7 per cent of capacity). This compares with 345,000 tons one week ago (12.2 per cent capacity), and 1,586,000 tons one year ago. Index of production for the week is 20.7.

Δ The Federal Reserve Board reported consumer instalment debt totaled $35,800,000,000 in June, an increase of $452,000,000.

Δ Government figures showed that manufacturers' inventories on June 30, amounted to, seasonally adjusted, $52,100,000,000, an increase of $500,000,000 during the month; June, 1959, sales amounted to $31,300,000,000, up $600,000,000 over the May, 1959, sales.

August 4

Δ July, 1959, assemblies of cars totaled 555,265 units, 73 per cent over July, 1958, production.

Δ Top executives of leading producers of farm machinery predict sales during the 1959 calendar year will reach $1,700,000,000, compared with $1,500,000,000 during 1958. Present sales are running 20 per cent of the like period of 1958 sales.

Δ The Aluminum Assn. reports that net shipments of aluminum sheet and plate for the first half of 1959 totaled 784,299,000 lb; shipments of aluminum foil for the same period totaled 120,501,631 lb.

August 5

Δ Shipments of iron and steel castings for May, 1959, totaled 1,455,081 tons compared with 1,471,020 tons in April, 1959, and 955,362 tons in May, 1958.

Δ AISI reported that a record 48,156,396 net tons of finished steel products were shipped during the first six months of 1959, shipments during the same period of 1958 totaled 28,699,218 net tons. Shipments for June, 1959, were 9,700,456 net tons compared with 8,754,119 tons in May, 1959, and exceeds June, 1958, shipments by about 69 per cent.

Δ The American Iron Ore Assn. reports that shipments of iron ore down the Great Lakes in July, 1959, totaled 6,845,309 gross tons compared with 9,589,436 tons in July, 1958; season cumulative totals to August 1, 1959, amounted to 35,577,842 compared with 21,753,570 tons in 1958.

Δ The American Iron Ore Assn. and AISI joint report indicates receipts of iron ore and ore agglomerates in the U. S. the second quarter of 1959 totaled 39,664,167 gross tons compared with 20,219,350 tons in the same period of 1958; stocks on hand at the end of this period amounted to, in 1959, 47,889,630 gross tons, in 1958, 52,497,184 gross tons; total consumption amounted to 34,519,397 gross tons, in 1959 and 18,824,452 tons in 1958.

August 7

ΔAuto dealers retailed 452,000 cars in July, 1959, down 22 per cent from June, 1959, but 30 per cent over July, 1958; stocks of U. S. built models climbed to 965,000.

Δ Colorado Fuel and Iron Corp. stockholders approved bond issue of $40,000,000 to be used to finance a $20,000,000 program of plant expansion and modernization and to simplify the corporation debt structure by retiring $6,500,000 in bank loans and redeeming $11,610,000 outstanding bonds of John A. Robeling's Sons Corp., a wholly-owned subsidiary.

Δ The Bureau of Mines reported that production of Pennsylvania anthracite for July, 1959, was 1,140,000 net tons compared with 1,683,000 tons in June, 1959, and 1,377,000 tons in July, 1958.

Δ According to report issued by F. W. Dodge Corp. construction contracts in the first half of 1959 totaled $18,900,000,000, 12 per cent ahead of the same period in 1958.

August 10

Δ Firth Sterling, Inc., reports for the second quarter of 1959 sales totaling $6,300,300, net income $135,200, or $0.08 per share compared with sales totaling $3,261,900, and loss at $271,500 or $0.20 per share for the same period of 1958; for the first half of 1959 sales totaled $11,776,500, net income $236,900 or $0.14 per share compared with sales of $6,924,100, and loss of $553,100 or $0.40 per share for the same time of 1958.

Δ Keystone Steel & Wire Co. reports for the fiscal year ended June 30, 1959, net sales totaling $120,071,295, net income of $9,075,374 or $4.84 per share; compared with year ending June 30,1958, sales of $97,706,805, net income of $5,984,595 or $3.19 per share.

Δ The AISI reports that the operating rate of the steel industry for the week of August 10 is scheduled at 332,000 tons (11.7 per cent of capacity). This compares with 318,000 tons one week ago (11.2 per cent capacity) and 1,632,000 one year ago. Index of production for the week is 20.7.

August 11

ΔSome 6000 members of the Mine-Mill Union and 2300 USW struck Kennecott Copper's four major mining properties when last minute negotiations failed to settle differences over the terms of new labor contracts.

August 12

Δ The Labor Dept. reported that employment in the month ended July 15 rose to 67,594,000 up 250,000; unemployment dropped to 3,744,000 a decrease of 238,000.

August 13

Δ Preliminary report of AISI showed production of ingots and castings during July fell to 5,233,000 net tons compared with 10,907,634 tons in June, 1959, and 6,442,405 tons in July, 1958.

August 14

Δ The Commerce Dept. reported that private housing starts in July, 1959, fell to a seasonally adjusted rate of 1,350,000 annually, down from the 1,370,000 pace of June, 1959.

August 17

Δ Continental Steel Corp. and the USW agreed on a new contract, which covers 2200 workers at the mill, providing for an agency shop, and also provides continuance of the contract until 30 days after the expiration of any new contract signed by the USW and big steel companies.

Δ The Dept. of Commerce and Dept. of Interior report that shipments of iron and steel castings for the year

1958 totaled 12,153,000 short tons, 21 per cent below the 1957 shipments. Production of steel ingots during 1958 amounted to 85,000,000 short tons, 24 per cent below 1957 production. Domestic consumption of ferrous scrap and pig iron in the U. S. during 1958 totaled 114,000,000 short tons, 24 per cent less than in 1957. Combined domestic stock of ferrous scrap and pig iron held by consumers as of December 31, 1958, totaled 13,558,000 short tons compared with 12,766,000 tons on December 31,1957. Inventories at the end of the year consisted of 9,594,000 tons of scrap and 3,964,000 tons of pig iron.

Δ The AISI reports that the operating rate of the steel industry for the week of August 17 is scheduled at 337,000 tons (11.9 per cent of capacity). This compares with 335,000 tons one week ago (11.8 per cent capacity) and 1,690,000 tons one year ago. Index of production for the week is 21.0.

August 18

Δ Canadian dollar rose to $1.05—3/16 in New York, up nearly 1/2¢.

August 19

Δ Commerce Secretary Mueller reported the gross national product in the second quarter of 1959 reached an annual pace of $484,500,000,000, an increase of $14,300,000,000 above the first quarter pace.

Δ The U. S. Bureau of Mines reported that marketed production of natural gas in the first quarter of 1959 totaled 2,977,560,000,000 cu ft, an increase of 2 per cent over the 1958 first quarter total; consumption reached a total of 3,543,300,000,000 cu ft, up 6 per cent over first quarter of 1958; withdrawals from storage in the period amounted to 316,900,000,000 cu ft.

August 20

Δ The ARCI reported that deliveries of new freight cars in July, 1959, totaled 4273 cars compared with 3950 in June, 1959, and 2113 in July, 1958. New orders for July, 1959, amounted to 4159 cars compared with 8054 cars in June, 1959, and 376 cars in July, 1958. Backlog of cars on order as of August 1, 1959, was 40,309 compared with 40,309 cars on July 1, 1959, and 25,994 on August 1, 1958.

Δ The Industrial Heating Equipment Assn. reported that new orders for industrial furnaces in July, 1959, were $13,141,000, compared with $7,029,000 in June, 1959, and $5,169,000 in July, 1958. New orders for induction heating equipment in July, 1959, totaled $1,911,000, a decline of 11 per cent from the June, 1959, volume.

August 21

Δ The A.F.L.-C.I.O. executive council expects the steel strike to last another month as indicated by setting aside one day, September 18, of its convention in San Francisco to demonstrate the federation's support of the striking steelworkers. The council also called on President Eisenhower to summon key officials of the steel industry and union to the White House to promote a settlement, and requested all affiliated unions to notify members of the importance of the steel strike in preparation of contributing to a financing drive.

Δ The Commerce Dept. reported U. S. export licenses for sale of goods to Russia in the second quarter of 1959 totaled $3,300,000, compared with $376,000 approved in the first quarter, but below the $5,100,000 approved in the final quarter of 1958.

Δ The Japan Iron and Steel Federation reports production of 1,359,000 metric tons of ingot steel in June, 1959, compared with 1,392,000 metric tons produced in May, 1959.

Δ Carpenter Steel Co. fiscal report for the year ended June 30, 1959, shows sales of $68,950,857, net income $4,594,850 or $5.00 per share, compared with 1958 fiscal year sales of $49,777,107, net income $769,723 or $0.85 per share.

August 24

Δ The AISI reports that the operating rate of the steel industry for the week of August 24 is scheduled at 343,000 tons (12.1 per cent of capacity). This compares with 321,000 tons one week ago (11.3 per cent capacity), and 1,715,000 tons one year ago. Index of production for the week is 21.4.

Δ The Aluminum Assn. reported that primary aluminum production in the United States during July, 1959, was 179,194 short tons compared with 167,323 short tons in June, 1959, and 118,541 short tons in July, 1958.

August 25

Δ St. Joseph Lead Co. increased price of lead by 1¢ to 13¢ a lb at New York.

Δ AISI, Committee of Stainless Steel Producers, reports that shipments of stainless steel for the first six months of 1959 totaled 390,133 net tons compared with 227,959 tons in the first half of 1958; ingot production in the first half of 1959 amounted to 739,764 tons compared with 379,179 tons in same 1958 period.

Δ Bureau of the Census, Industry Div., reports that 444,711 tons of steel were consumed by can manufacturers during June, 1959, an increase of 8.8 per cent over June, 1958; for the first six months of 1959 the can industry consumed 2,190,212 tons of steel, an increase of 5.3 per cent over the same period of 1958.

August 26

Δ The AISC reported that bookings of fabricated steel in July, 1959, totaled 259,131 tons compared with 290,911 tons in June, 1959, and 330,890 tons in July, 1958; shipments in July, 1959, amounted to 238,559 tons compared with 365,434 tons in June, 1959, and 290,856 tons in July, 1958. Backlog of future work as of July 31 totaled 1,678,852 tons.

Δ Edison Electric Institute reported that electricity output in the week ended August 22 totaled 14,003,000,000 kwhr, a new record.

August 28

Δ The Commerce Dept. estimated that construction put in place in August reached $5,300,000,000, compared with $5,200,000,000 in July, 1959.

Δ F. W. Dodge Corp. reports that construction contracts in the United States for July, 1959, amounted to $3,656,537,000, one per cent above July, 1958, total.

August 31

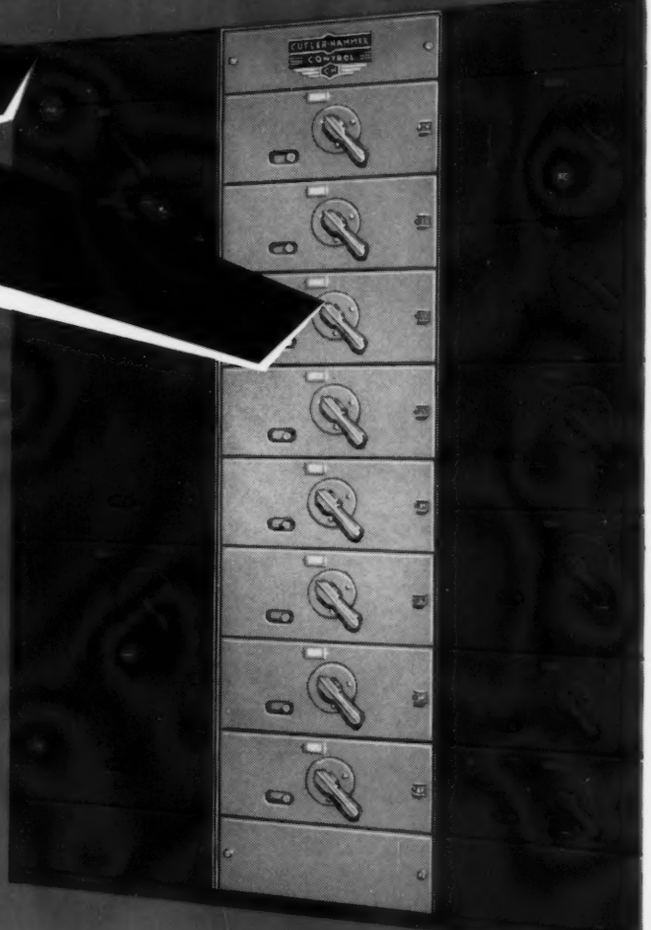
Δ The Commerce Dept. reported that manufacturers' inventories in July, 1959, rose to a seasonally-adjusted $52,200,000,000, a gain of $100,000,000 over June, 1959; manufacturers' sales in July totaled an adjusted $30,800,000,000, a drop of $400,000,000 from June, 1959.

Δ American Metal Climax, Inc. increased price of copper 3¢ to 33¢ per lb.

Δ The AISI reports that the operating rate of the steel industry for the week of August 31 is scheduled at 345,000 tons (12.2 per cent of capacity). This compares with 332,000 tons one week ago (11.7 per cent capacity) and 1,666,000 tons one year ago. Index of production for the week is 21.5.

Δ Premium grade steel scrap prices in Chicago increased $2.00 to $3.00 a ton; No. 1 industrial bundles sold from $43.50 to about $45.00, delivered, compared with $41.50 a month ago and a mill sale of $42.50 about two weeks ago. Other scrap grades are up $2.00 to $3.00; No. 1 heavy melting steel quoted at $38.00, No. 2 at $35.00.

Looking for Something EXTRA!



New 8-Hi Unitrol® saves valuable space without sacrificing Structural Stability, Flexibility, or Installation Simplicity

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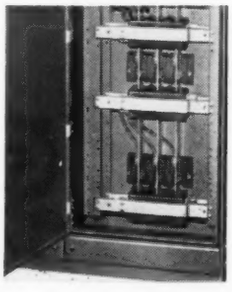
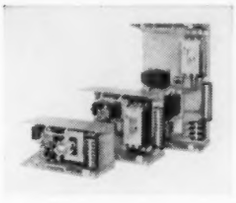


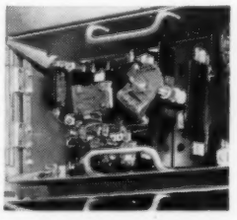
8-Hi Unitrol is built better to last longer

The new 8-Hi Unitrol is first to achieve a truly compact design without sacrificing structural stability. 8-Hi Unitrol retains all the extra construction features which earned Unitrol the reputation for outstanding ruggedness and dependability. Make your own comparisons and you'll agree 8-Hi Unitrol is built better . . . will last far longer.



8-Hi Unitrol offers extra control center flexibility

Here's *extra* value at *no* extra cost. 8-Hi Unitrol Control Units are available in both the standard and the new compact design for greater selectivity and flexibility. Add to this the modular unit construction and see how 8-Hi Unitrol not only affords greater space-saving, design flexibility, but also simplifies on-the-job modifications to keep pace with the user's changing control requirements.



8-Hi Unitrol is easier and safer to install

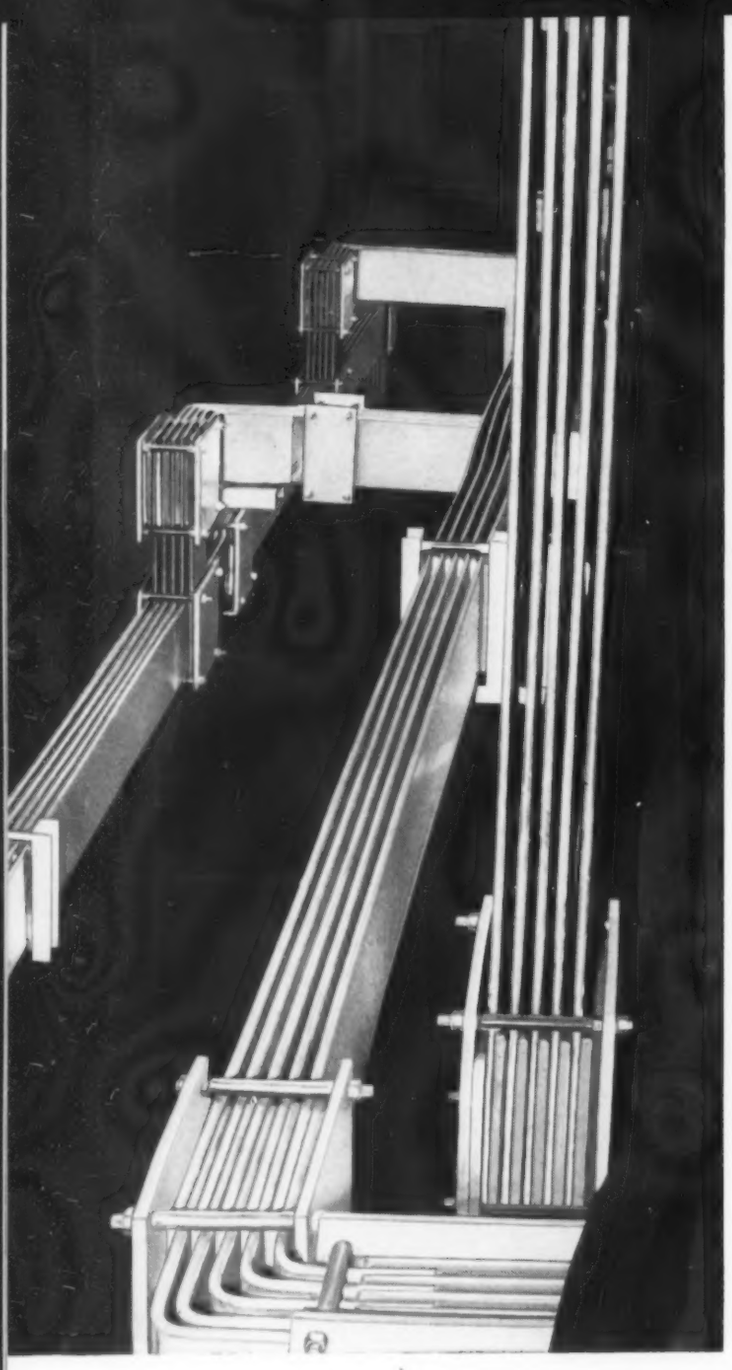
Available in type A, B, and C construction with class 1 or 2 wiring, you can choose the 8-Hi Unitrol that affords the greatest installation economy. U-shaped plug-in control units eliminate buried components . . . provide wide-open accessibility and visibility. Exclusive "safety-lock" test position insures safe assembly, wiring and testing of every control unit. Plug-in power contacts are self-aligning . . . eliminate hazardous manual adjustments.

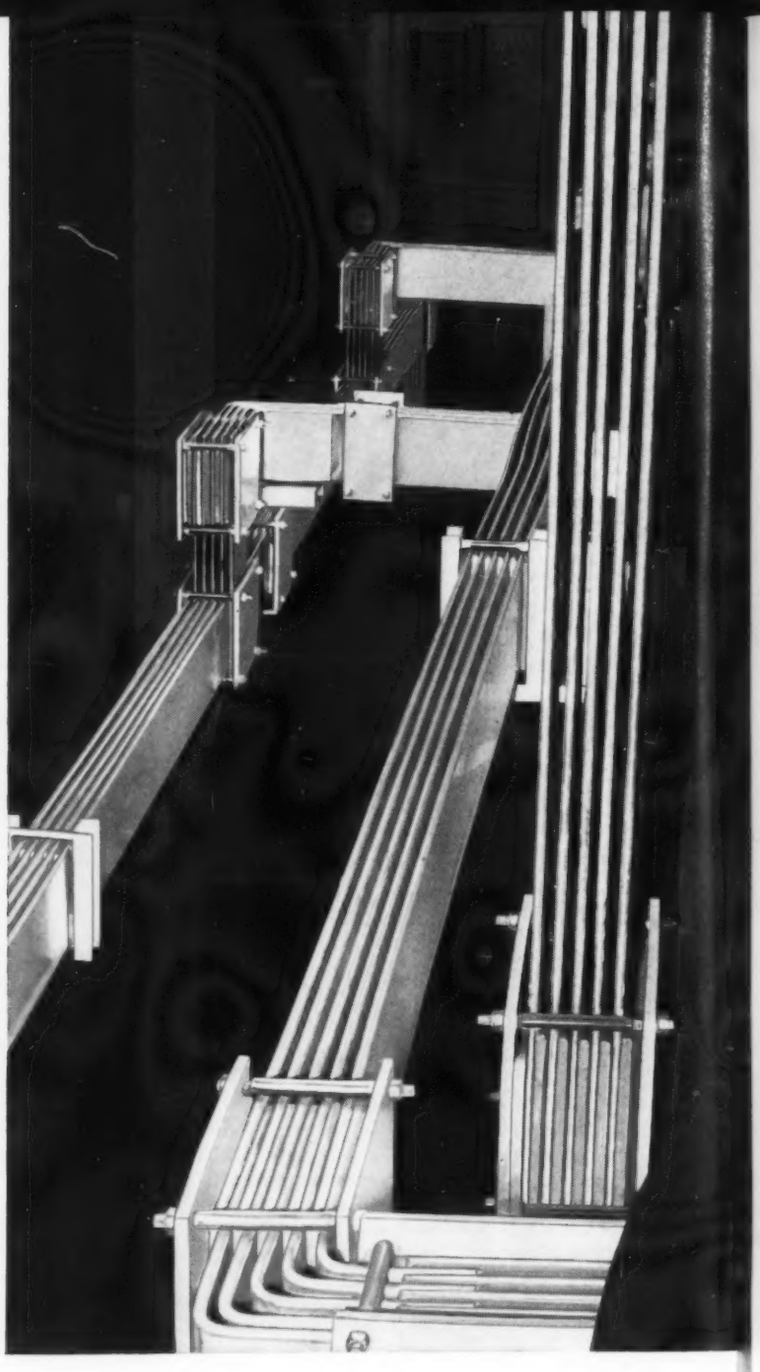
Be sure you have all the facts on the new Cutler-Hammer 8-Hi Unitrol today . . . its many extra features assure you easier, more economical installations; and longer lasting, trouble-free operation for its user. Write now for the new descriptive Bulletin EN 142-T232.
CUTLER-HAMMER Inc., Milwaukee 1, Wisconsin.

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.





WITH ALCOA ALUMINUM BUS CONDUCTOR...

twice as much for the same price

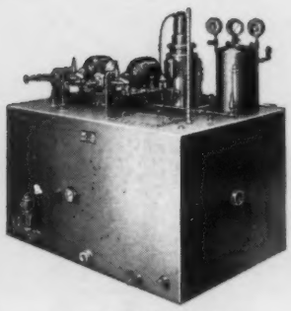
IT'S TRUE–for conductors with the *same* electrical and heat-dissipating ratings, you can buy, today, *two* feet of Alcoa bus for the price of just *one* foot of copper.

BUT MATERIAL cost is only part of the story. Lightweight Alcoa® Aluminum Bus Conductor handles more easily and requires less costly supporting structures. It's easier to bend and form to your needs. Millions of pounds of aluminum bus are in service today in all types of industry.

SO WHY ever use *any* bus except Alcoa Aluminum? There's not a reason in the world . . . not these days! For up-to-date facts and figures on how much *you* can save, call Alcoa or your Alcoa Distributor. Aluminum Company of America, 2113-J Alcoa Building, Pittsburgh 19, Pennsylvania.

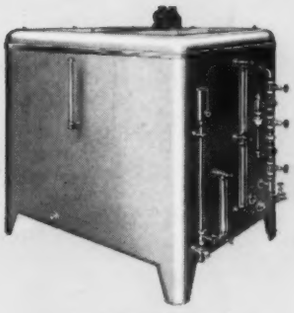
Write on company letterhead for *Alcoa Aluminum Bus Conductor Handbook*

ALCOA ALUMINUM



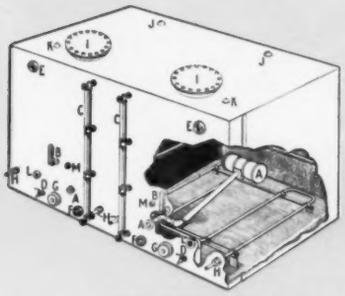
SPACE SAVING LUBRICATION SYSTEM

Figure 829 Self-Contained Lubricating Units offer a complete oil circulating and filtering system . . . compactly designed with filter, pumps, pressure tank, piping, alarms, gauges, etc.



OIL CONDITIONER

Figure 832-P — Filters and conditions turbine and other low viscosity, high demulsibility oils . . . without aeration, turbulence, heat or the use of moving parts.



RECEIVING AND STORAGE TANKS

Figure 363 — Two-Compartment Storage Tank permits precipitation of dirt and water from one batch while other batch circulates through system. Capacities 300 to 8,000 gallons.

Figure 360 — Receiving Tank receives dirty oil by gravity . . . precipitates dirt and water before pumping to filter. Capacities 100 to 6,000 gallons.

specify BOWSER

LUBRICATION & FILTRATION

equipment

NOW!

"CUSTOM ENGINEER" your next lube system for big savings • unmatched performance . . . with this full line of advanced lubrication & filtration equipment! All sizes and capacities.

BOWSER ESTABLISHED 1885 INC.

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Bowser cooperates by furnishing complete data for any specific installation or catalogs for engineering files . . . send coupon.

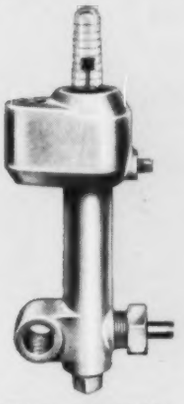
Date _____

MAIL TO:
BOWSER, INC.
1300 E. Creighton Ave.
Fort Wayne, Indiana

Gentlemen: Please send prices and detailed information on:

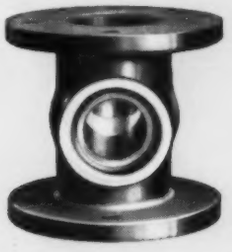
- ☐ Figure 829 Lube System
- ☐ Receiving & Storage Tanks
- ☐ Flow Sights
- ☐ Figure 823-P Oil Conditioners
- ☐ Figure 818 Oiler
- ☐ Teleflow Indicator

(Attach to your letterhead for quick response.)



SIGHT FEED OILER

Figure 818 — Pressure-type oiler features location of indicator outside the liquid body making it ideal for use with dark liquids.

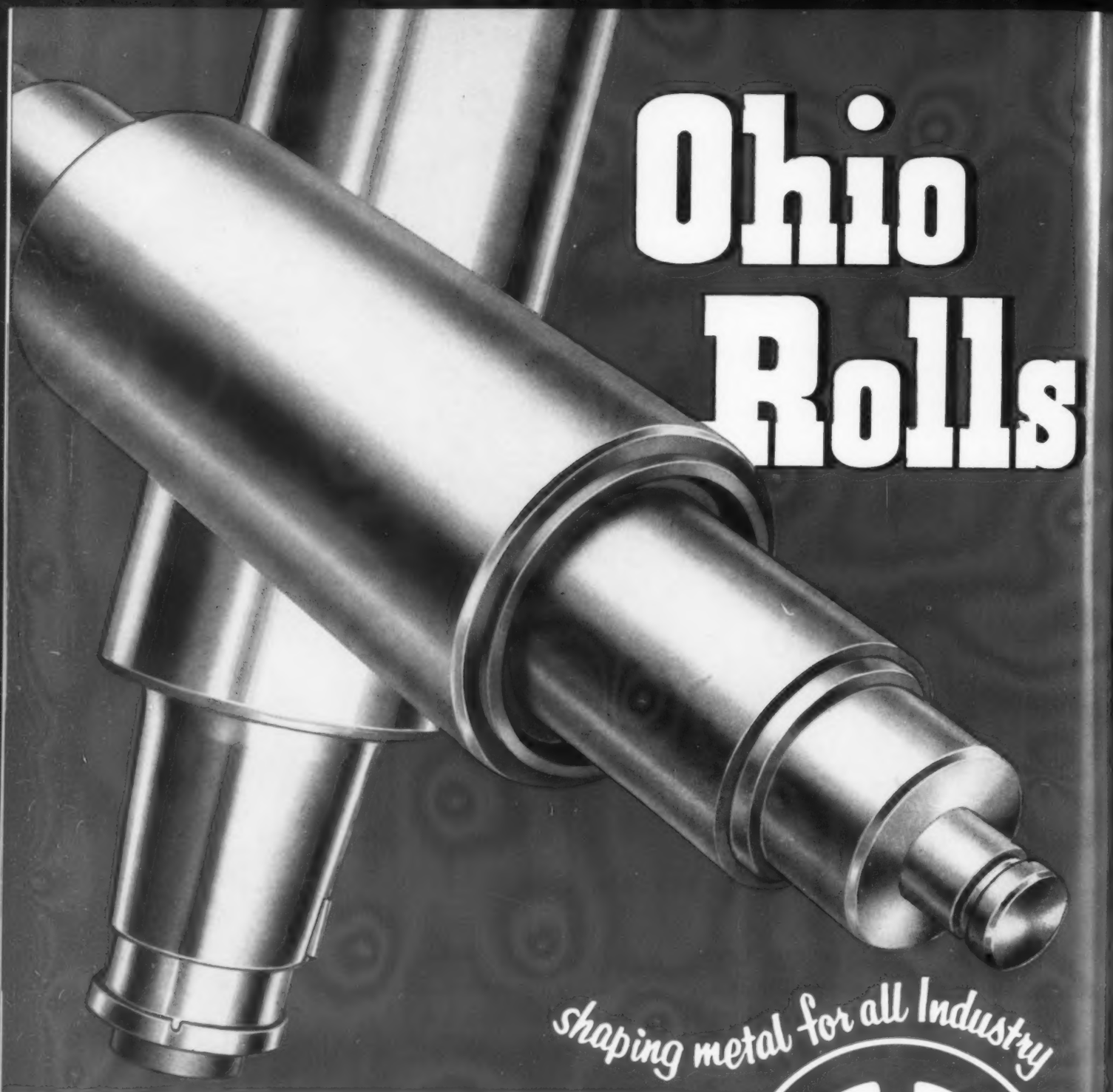


FLOW SIGHTS

Double window flow sights for vertical installation on gravity flow lines. Flow is clearly visible . . . glasses do not cloud.

TELEFLOW INDICATOR

Figure 815 offers easy reading graduate dial for close approximation of liquid in flow. Vane type indicators also available.



Ohio Rolls

shaping metal for all Industry

OHIO IRON AND STEEL ROLLS

Carbon Steel Rolls
Ohioloy Rolls
Ohioloy "K" Rolls
Nioloy Rolls
Flintuff Rolls
Double-Pour Rolls
Chilled Iron Rolls
Forged Steel Rolls
Denso Iron Rolls
Nickel Grain Rolls
Special Iron Rolls

The Ohio Steel Foundry Co.

LIMA, OHIO

LIMA... Virtually at the center of the steel industry

PLANTS AT LIMA AND SPRINGFIELD, OHIO

Industry News...

NATIONAL STEEL AWARDS ADDITIONAL CONTRACTS

△ National Steel Corp. has awarded additional contracts for major work at two plant locations in its current $300,000,000 expansion program, it was announced by William P. Hill, vice president—engineering.

The contracts are for slab reheating furnaces at Great Lakes Steel Corp., and for foundation work at Great Lakes Steel and at Midwest Steel Corp.

Salem-Brosius, Inc., has been awarded a contract for four 5-zone slab reheating furnaces which will be the largest of their type in the world. Rated at a combined productive capacity of 1000 tons of 30-ft long slabs per hour, the furnaces will be used for reheating slabs prior to rolling in Great Lakes' new 80-in. hot strip mill.

Eichleay Corp. and the Walsh Construction Co. have jointly been awarded the contracts for foundation work at Great Lakes Steel Corp. and Midwest Steel Corp.

At Midwest Steel the contract includes the following work: site preparation for all equipment and buildings, excavations and foundations, underground storm, sanitary and industrial waste sewers, drinking and service water lines, roads, railroad trackage and flooring.

The contract at Great Lakes Steel is for all foundations, including piling, and other work required for the expansion of Great Lakes Steel facilities to accommodate the new 80-in. hot strip mill.

GARY 10-IN. BAR MILL TO BE MODERNIZED

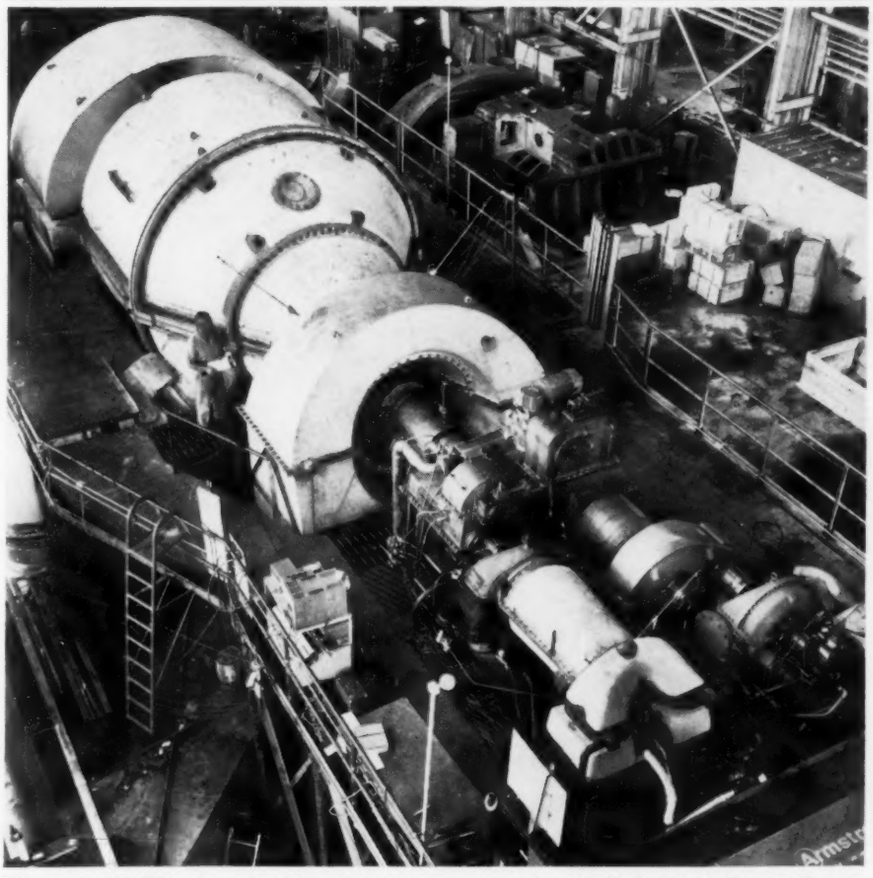
△ Bars in coils up to 2100 lb, among the heaviest produced in the industry, will be available for the first time at Gary Steel Works of United States Steel Corp. with the modernization of the 10-in. No. 4 bar mill.

In making the announcement of the coming improvements to the mill, T. W. Hunter, general superintendent, said that contracts for equipment have already been let.

When modernization has been completed, the mill will consist of 16 stands and roll at a design speed in excess of 2000 fpm with improved quality and product line.

The mill has been rolling carbon

GAS TURBINE BLOWING UNIT ON TEST



The new 125,000-cfm blast furnace blowing unit for the U.S. Steel Corp.'s South Works was recently visited by many steel plant executives while on test. At the right-hand side of the figure is shown the starting apparatus and the blast furnace fuel gas compressor followed by the air intake for the multi-stage axial flow compressor and the housing for the gas turbine proper. Below the floor line is located the combustor.

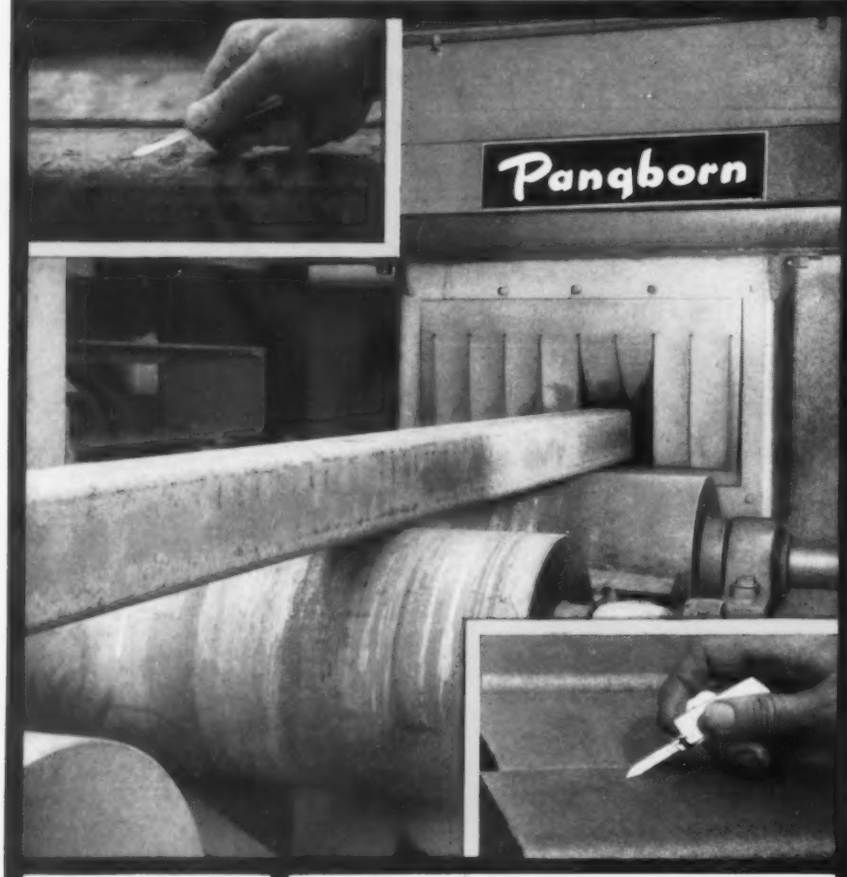
This unit will be the first of its kind to be used by the American steel industry to drive a blast furnace blower deriving its energy from blast furnace gas. The system is designed to supply 125,000 cfm of air at a pressure of 35 psig.

Shop testing showed a maximum capability of 135,000 cfm as opposed to the designed capability of 125,000 cfm while operating at 35 psig discharge pressure. Preliminary engineering tests show the over-all operating field of the gas turbine blowing unit to be better than originally anticipated. The unit may be capable of operating through the entire pressure and flow ranges without the benefit of external blowing controls.

More than seven years of research went into this project in an effort to determine the advantages of this new system in comparison to existing methods of blast furnace blowing. The findings revealed that the gas turbine system was not only lower in first cost, but the operating and maintenance cost would be less. Also, the gas turbine system requires less space and can be made to utilize no water.

The new Westinghouse gas turbine system eliminates the need for a boiler in its auxiliary equipment since the blast furnace gas is burning directly in the gas turbine. The connected axial compressor not only supplies air to the blast furnace, but it also furnishes air to the combustion system of the gas turbine.

GIVES "JUST RIGHT" DESCALING!



Large steel producer uses Rotoblast descaling for exact cleaning quality

To facilitate inspection for flaws, one of the country's leading steel producers cleans ¾-ton billets with a special Rotoblast descaling machine. Because cleaning time depends on the varying steel composition of the billets, this machine is equipped with six speed settings. According to company supervisors, the quality of Rotoblast cleaning is "just right" . . . all loose scale is removed for easy inspection without overblasting to peen over and hide flaws. What's more, Rotoblast operation is reported to be efficient, dependable and trouble-free.

If you have a standard or special descaling problem, your solution is Pangborn Rotoblast. Ask the Pangborn man in your area or write PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment — Rotoblast Steel Shot and Grit.*

Pangborn

CLEANS IT FAST WITH ROTOBLAST®

bar flats, automotive alloy spring steel flats and carbon concrete reinforcing bars. The new product line will be expanded to include rounds, squares and hexagons in sizes ⅜ in. to 1½ in. This program will result in a new source of supply to meet the growing demands of the fastener, cold finished bar, automotive and many other industries for bars in large coils.

Expected completion date is scheduled for the third quarter of 1960.

PLATE MILL CONTRACT AWARDED TO MESTA

△ A contract covering the design and manufacture of a 132-in. four-high reversing plate mill and auxiliary equipment for Republic Steel Corp. at Gadsden, Ala., has been awarded to Mesta Machine Co.

Designed to roll reheated slabs into plate up to 126 in. wide and operate as a reversing rougher to produce breakdowns for the hot strip mill, the new equipment will include a vertical edging mill; 132-in. four-high reversing plate mill with front and rear mill tables, adjustable sideguards and individually driven tapered rollers for slab turning; a vertical edging mill operating in tandem with the plate mill; and a mill runout table.

An automatic programming system will be provided for the control of edging roll adjustment and main drive of the No. 2 vertical edging mill, and for roll opening, speed and direction of the plate mill. Backup rolls on the plate mill will be mounted in oil bearings, with work rolls mounted in roller bearings and individually driven by direct-connected 5000 hp motors.

Mesta will provide hydraulic roll balance, descaling and roll cooling systems, and oil and grease lubricating systems for the plate mill equipment.

TO BUILD REFRACTORIES PLANT IN GARY, IND.

△ E. J. Lavino and Co. has announced that it will build a multi-million dollar basic refractories plant in Gary, Ind., on 32 acres of land recently purchased for that purpose. Clearing and filling of the land is already underway.

Lavino has a basic refractories plant at Plymouth Meeting, Pa.,

LUKENS STEEL COMPANY'S NEW ELECTRICAL FURNACE draws power from the new Brandywine main substation by 15kv, single conductor, 600 MCM Okolite-insulated cable in underground ducts. New furnace is part of Lukens' plant expansion program, designed and constructed by United Engineers and Constructors Inc. of Philadelphia.

How Okonite dependability protects plant profits at Lukens Steel

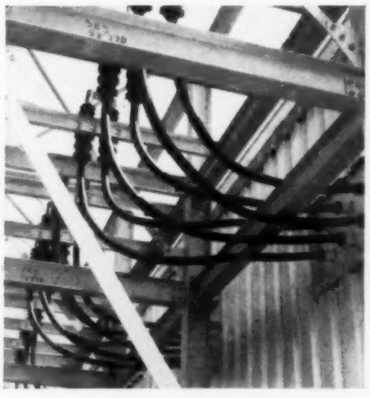
Lukens Steel Company, like thousands of leading corporations throughout the world, makes extensive use of Okonite cable for its crucial electrical circuits. They have found that long-lived, dependable Okonite cables are indispensable on important applications to maintain profitable production—an assurance based on the excellent service records of Okonite cables in their own and other plants. There are four basic reasons for these service records:

1. **Engineering experience,** derived from developing long-lived cables for every type of industrial application.
2. **Quality materials,** maintained without compromise for every component and through every stage of manufacture.
3. **Manufacturing skill,** achieved by 80 years' work with all known insulating methods.
4. **Quality control,** assured by the strictest, most thorough testing methods in the industry.

These four basics mean that Okonite cables will be able to meet your most challenging specifications with long-lasting protection, maintenance-free service. This is typified by the proved service record of Okolite insulation—used by Lukens Steel for its critical high voltage feeders. This insulation has a 30-year record in all types of installations demanding resistance to ozone, moisture and heat, as well as high dielectric strength.

Send for more information about this long-lived, widely used insulating material and its applications.

NATION'S LARGEST ROLLING MILL—Lukens' 206-inch mill is a good example of essential mass production equipment whose continuous operation is assured by the use of Okonite cables in crucial power circuits.

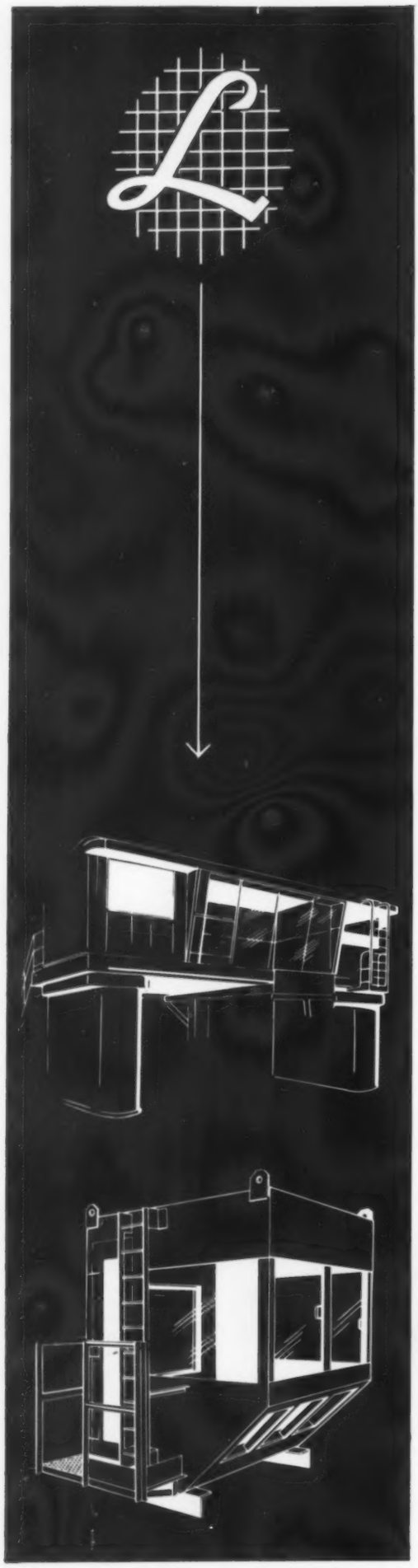


LUKENS' BRANDYWINE SUBSTATION steps down power for the existing Lukens plant and proposed expansion. From this key substation the main feeder for the expansion is Okolite-insulated cable for 23kv ungrounded service—a tribute to Lukens' past experience with Okonite cables.

THE OKONITE COMPANY
Subsidiary of Kennecott Copper Corporation
Passaic, New Jersey

where there's electrical power . . . there's **OKONITE CABLE**

8545



The overwhelming majority of cranes and pulpits are equipped with

Lintern

Aire-Rectifiers

The reasons why are contained in Bulletin AC-573. May we send you a copy?

The Lintern line includes heaters, Glo-lites, crane sanders, and crane cabs. Consider these products in your modernization programs.

Larco, inc.

DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS

ROUTE 20 EAST, PAINESVILLE, OHIO

and another at Newark, Calif. The new plant in the midwest will round out its locations close to all the major steel and other metals producing areas in which most of Lavino products are consumed.

JOINT FORMATION OF CHILEAN FIRM ANNOUNCED

△ A new Chilean corporation, Armco Chile S.A., of Santiago, has been formed by the Armco International Corp., and Compania Electro Metallurgica S.A., of Santiago, Chile. This joint venture will produce grinding media to be used chiefly by the Chilean copper mines.

The new company has been capitalized at $2,400,000.

Armco Chile's new plant will be located on a ten acre site at Huachipato immediately adjacent to the integrated steel plant, Compania de Acero del Pacifico S.A., which will supply steel required in the manufacture of products made by the new enterprise.

Facilities for forging, heat treating and other processes necessary for the production of high quality grinding balls, will be installed.

Locally produced as well as imported materials will be used in the construction of the Huachipato plant, completion of which is expected in 1960–61.

MESTA TO FURNISH COLD ROLLING UNITS

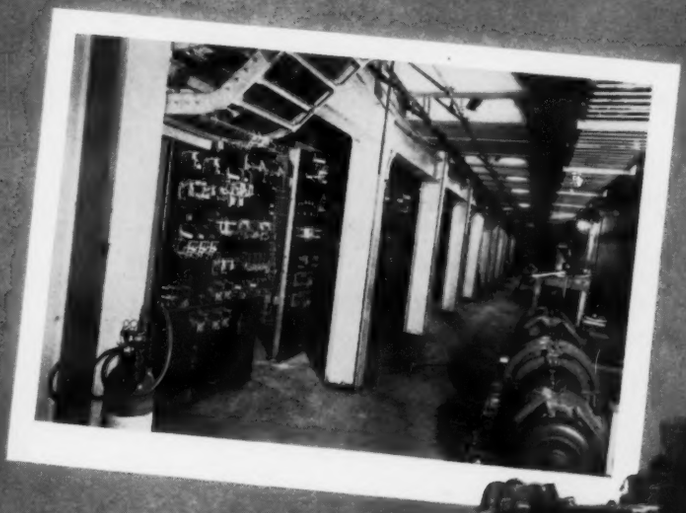
△ Mesta Machine Co. has been awarded contracts covering the design and manufacture of cold rolling facilities for the new Indiana plant of Midwest Steel Corp. Mesta will build a 52-in. five-stand tandem cold mill and a 52-in. twin-stand skin pass mill.

The five-stand mill will be designed to reduce hot rolled strip to gages of 0.063 in. to 0.0043 in. x 48 in. wide, and the two-stand mill to impart the desired temper to these gages following an annealing operation. Each mill will be able to produce 90-in. diam coils weighing up to 80,000 lb, at strip speeds of 6000 fpm. Main drives for the five-stand mill total 25,990 hp, applied through pinion stands for No. 1 and No. 2 mill stands, and by twin drives for stands No. 3 through No. 5. Temper mill drives total 3000 hp,

(*Please turn to page 219*)

MURRAY WORKS

FOR THE STEEL INDUSTRY



• The Murray organization is right at home working on assignments in the steel industry. This is readily understandable . . . for we have completed a varied range of installations in plants throughout the industry.

The continuous strip galvanizing line shown here included complete installation and design.

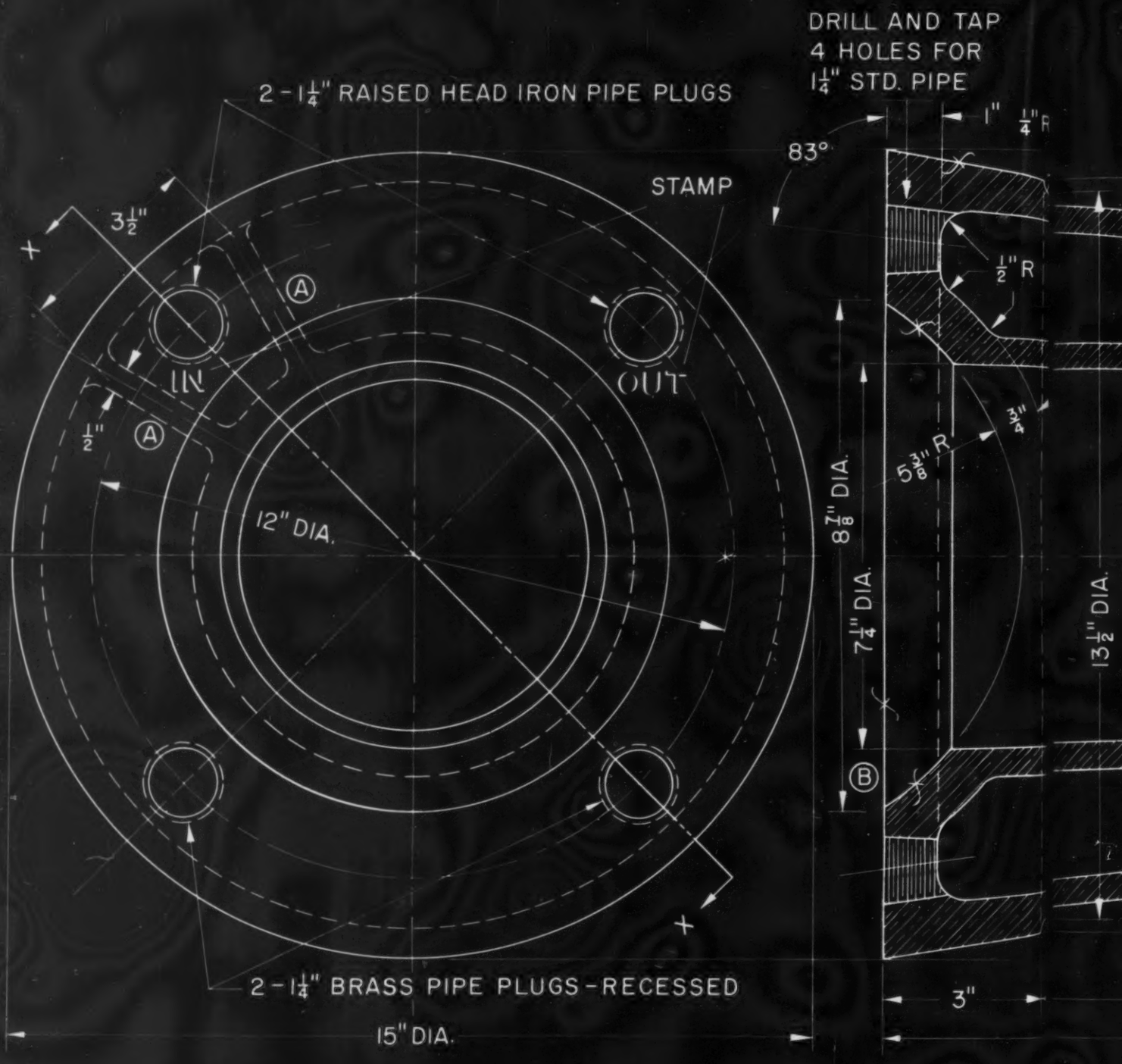
• If you are planning an expansion program and prefer outstanding performance in construction and installation, you'll find it good business to write or call Murray — First!

DAVID W. MURRAY COMPANY

DETROIT • TOLEDO • CLEVELAND • PITTSBURGH

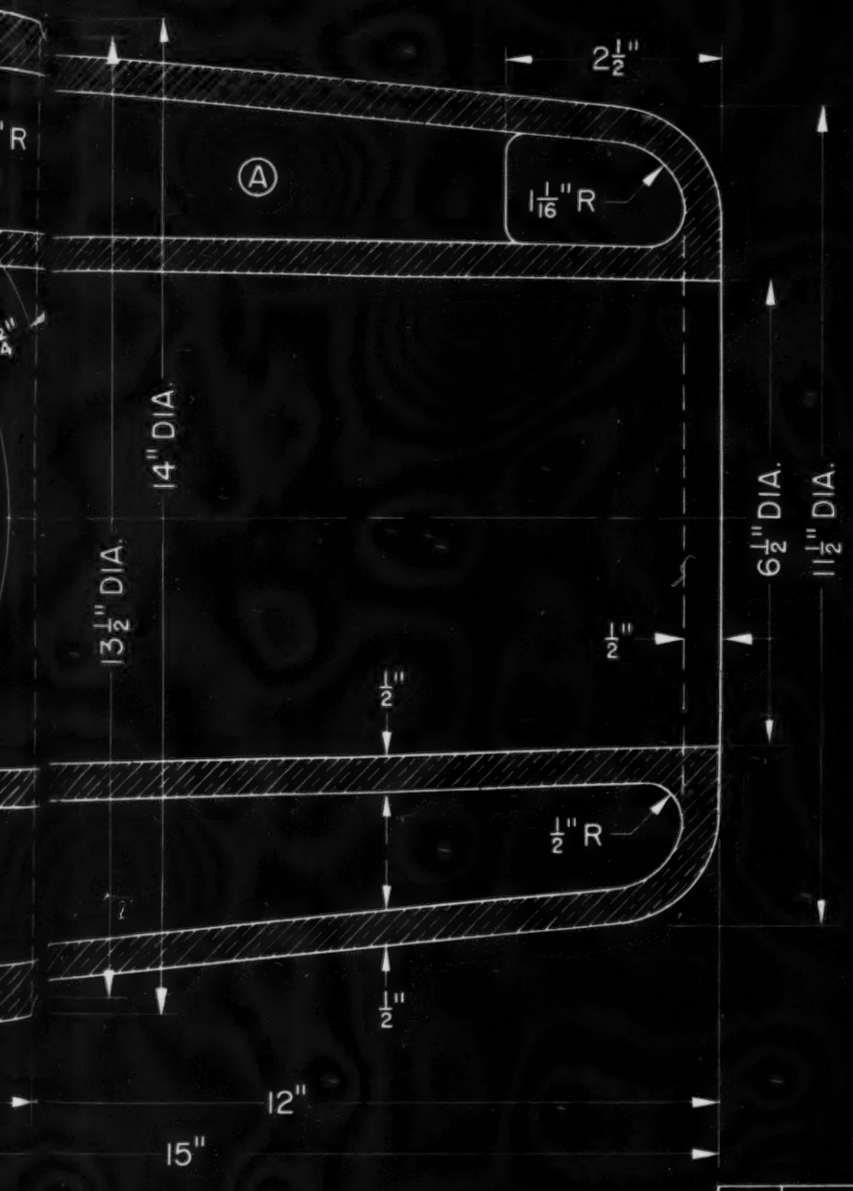
MAIN OFFICE • P. O. BOX 4768 • CLEVELAND 26, OHIO

FILE: BLAST FURNACE - COPPER TUYERE



RIGGING (PATTERN) NO. 3462

PATTERN	3462
SHELL BOX	1777
PLUG	3020
CENTER BOX	3020
PRINT	3020



SECTION X-X

PRODUCTION SPECIFICATIONS

MATERIAL: Electrolytic Copper

STANDARD INSPECTION:

1. Conductivity (I.A.C.S.). Heat Only.
2. Hydrostatic Test - 100 psi
3. Dimensional Check - Gauge
4. X-Ray - Pilot Castings

SPECIAL INSPECTION - See Shop Order for Customer Specifications:

1. Conductivity Report on Each Tuyere
   - a - 70% min. (I.A.C.S.)
   - b - 80% min. (I.A.C.S.)
   - c - 90% min. (I.A.C.S.)
2. Steam Test - 100 psi
3. X-Ray Test - Individual Tuyeres
4. Certified Chemical Analysis

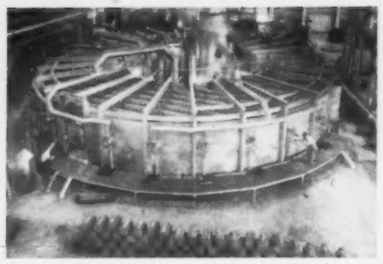
REFERENCE DRAWINGS:

K-55884	–	8½"	x 15"
L-56976	–	7"	x 15"
K-56961	–	7"	x 12"
K-56820	–	6½"	x 12"
L-57164	–	6"	x 15"
K-57081	–	6"	x 12"
K-56889	–	5½"	x 15"
K-56188	–	5½"	x 12"
K-56846	–	5"	x 15"
K-57180	–	5"	x 12"
K-56590	–	4½"	x 12"

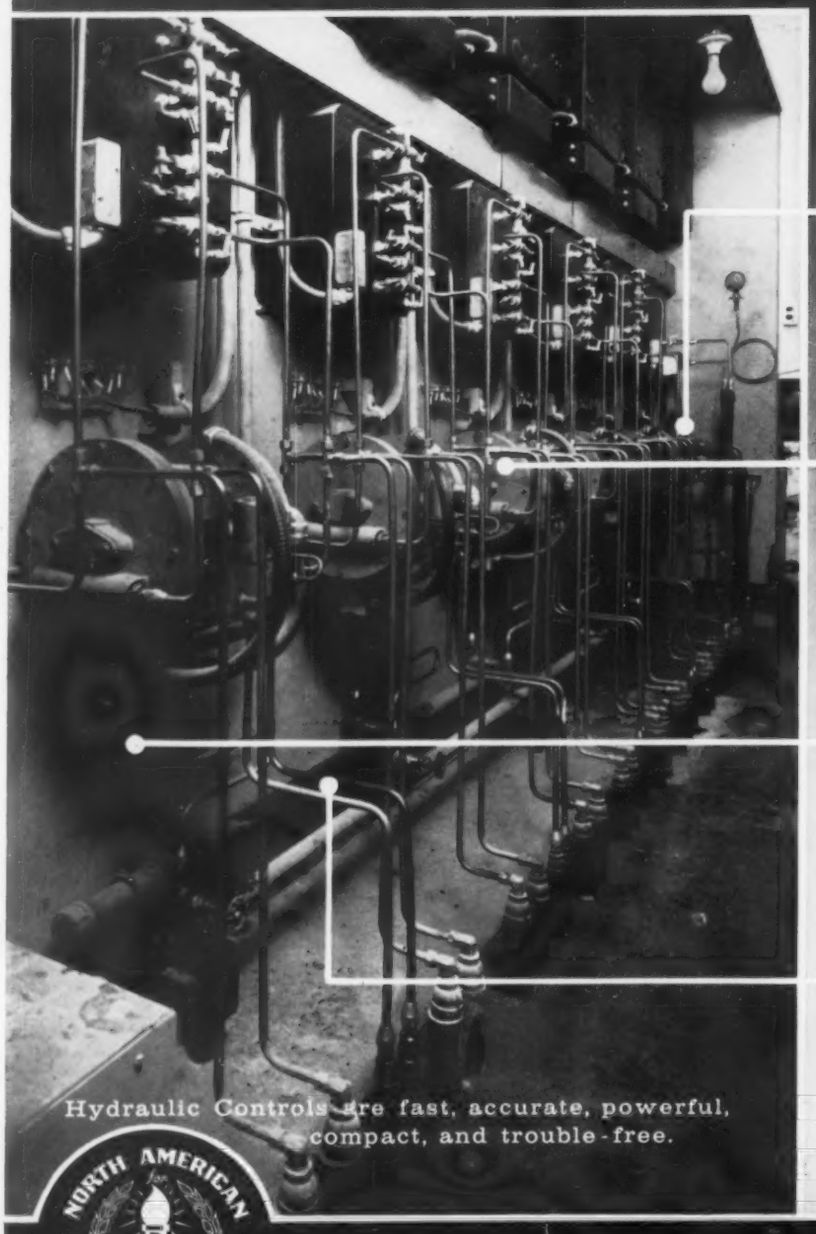
REV.	DESCRIPTION	DATE	DR.	CK.
B	ADD ∫ BUTT END	3/6/57	H.W.	J.S.
A	RIBS ADDED	2/1/57	H.W.	J.S.

DRN. H.W.	NATIONAL BEARING DIVISION	
CHK. J.S.	717-D GRANT BLDG., PITTSBURGH 19, PA. PLANT: MEADVILLE, PA.	AMERICAN Brake Shoe COMPANY
DATE 1/21/56		
SCALE 3/8" = 1"	6½" X 15" STANDARD TUYERE	
CUSTOMERS NO. E-66293	SHEET 1 OF 1	L-56432

Canadian Steel Wheel Ltd. uses combustion controls by North American



60′ Rotary Furnace heats 348 blocks (foreground) for press forging railway wheels.



Furnace Pressure ±0.0025" wc — controlled by this North American 16" diaphragm Regulator operating the damper on a 60′ CANEFCO furnace.

Fuel-air ratio set on control panel for each of 5 zones is *accurately maintained* at all flow rates by North American Regulators. Flow is controlled by North American crank type cylinders on remote fuel valves.

Light weight and compactness allow regulator to be bolted directly on instrument panel without supports. Manual operation is achieved by panel-mounted push-button positioning of the fuel valves.

Pressurized return lines permit low cost installation using small tubing. Pump can be above or below unit.

Hydraulic Controls are fast, accurate, powerful, compact, and trouble-free.

For engineering information, call your nearby North American Combustion Engineer or write for Bulletins

6-003
7-001

NORTH AMERICAN for COMBUSTION and Hydraulic Controls

The North American Mfg. Co.
Cleveland 5, Ohio

(*Continued from page 214*)

with the bottom backup rolls direct driven through gear-type spindles.

Coil handling equipment, capable of maintaining a steady flow of 80,000 lb coils, will be installed with each mill, including entry coil conveyors with a capacity of six coils, coil transfer units, elevating strippers and six-station delivery conveyors with load cell scales and automatic recording equipment. Strip for the five-stand mill will be fed through pinch rolls and a straightener from a coil box with rotating disk sideguards, served by a coil positioner, coil pusher and coil opener. The two-stand mill will feature a feed reel of the double overhung-mandrel type with automatic side register control, entry and delivery tension devices, and crop shears at both ends of the mill. Strip will be re-coiled at both mills on tension reels with overhung mandrels and outboard bearings.

Mesta will also provide auxiliary hydraulic systems, and oil and grease lubricating systems for each mill.

PECOR TO BUILD TWO J & L OXYGEN FURNACES

△ Pennsylvania Engineering Corp. has received an order from Jones & Laughlin Steel Corp. to build the two largest basic oxygen steel furnaces in the world.

The furnaces will be installed at J & L's Cleveland Works and are expected to produce up to 200 tons of steel per heat.

Pennsylvania Engineering Corp. previously built the two 65/100 ton furnaces installed in J & L's Aliquippa Works, which were the world's largest at that time.

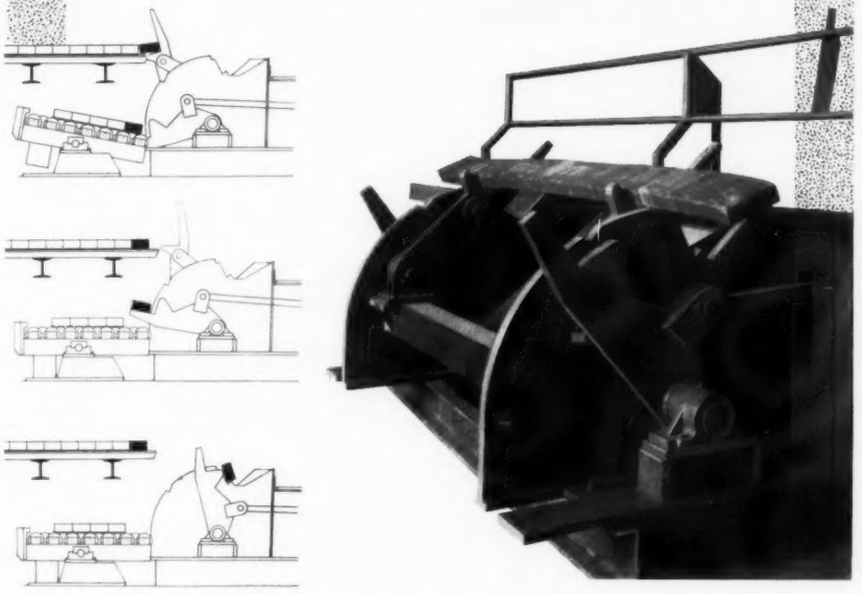
Pecor has fabricated all of the basic oxygen furnaces (L/D) now installed in this country.

Meetings

△ The Galvanizers Committee of the steel industry, which is sponsored by the American Zinc Institute, will hold its 41st meeting on October 22–23, 1959, at the St. Francis Hotel, Canton, Ohio. This committee consists of technical and operating representatives of those major steel producers in the United States and Canada who are also engaged in galvanizing sheet or pipe.

The New EVANS SLAB and BILLET TURNER

for faster, lower cost steel conditioning



- Fast positioning, turning and unloading
- Easy accessibility for scarfing and inspection
- Complete operator control

Specialists in the design and manufacture of special turning equipment, Evans engineered this new slab and billet turner to cut costs two ways—by increasing production and reducing handling costs. Used with a feed mechanism, the turner swiftly positions either slabs or billets one piece at a time. Positive turning action brings each edge or face into convenient work position and then quickly unloads the work piece onto a delivery rack.

The operator's platform is clean and uncluttered. Simple push button operation affords him complete control, and easily controlled position variation insures efficient scarfing and inspection.

Rugged all-weld construction and positive mechanical linkage provides capacity for handling slabs up to 14 inches wide in 10 to 30 foot lengths, or billets of the same length, and any cross section, within the turner's 6000 pound weight limit.

Consult Evans for specialized engineering assistance to help cut turning and handling costs and boost production. Write for a new two-color brochure that fully describes Evans' Special Turning Equipment.

EVANS INC.

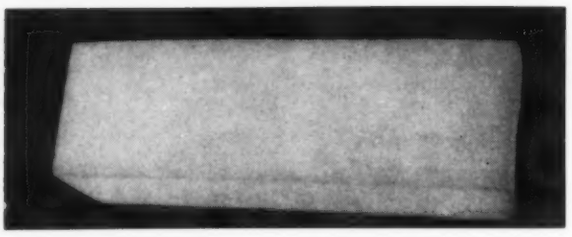
EVANS ENTERPRISES
INCORPORATED
MASSILLON, OHIO

HYDRA-JET DESCALING FACILITIES

Remove Scale 100% With Practically No Cooling of the Steel

Before Descaling

After Descaling



Best place to start the descaling is on the ingot ahead of the Slabbing or Blooming Mill.

Why roll the scale in and later use enormous quantities of water trying to get it out?

COMMERCIAL SHEARING AND STAMPING
Youngstown, Ohio — Chicago, Illinois — Salt Lake City, Utah

HARMON AND COMPANY
Exclusive Hydra-Jet Descaler Sales Representatives
919 N. Michigan Ave., Chicago 11, Illinois, Tel. SUperior 7-6628

Robinson Refractories Serve You Best!

No matter what your requirements, it pays to specify Robinson Refractories

- **Advanced production techniques**
- **Modern manufacturing equipment**
- **Rigid quality control**
- **Field engineering service**
- **15 completely stocked branches**
- **Fast, dependable delivery**
- **Complete line for all your needs**

New! Robinson Kiln Car and Floor Block. Write for Complete-Line Refractories Catalog.

THE ROBINSON CLAY PRODUCT CO.
ESTABLISHED 1856
AKRON 9, OHIO

15 ROBINSON BRANCHES TO SERVE YOU BEST

AKRON, OHIO • ALBANY, N. Y. • BALTIMORE, MD. • BLOOMFIELD, N. J. • BOSTON, MASS. • BUFFALO, N. Y. • CHICAGO, ILL. • EAST HARTFORD, CONN. • INDIANAPOLIS, IND. • MT. VERNON, N. Y. • NEW YORK, N. Y. (JAMAICA, L. I.) • PHILADELPHIA, PA. (POTTSTOWN, PA.) • ROCHESTER, N. Y. • SYRACUSE, N. Y. • CONCORD, ONTARIO, CANADA

R 359-136B

FELLER ENGINEERING

presents

SCHLOEMANN

Reversing strip rolling mills for steel and non-ferrous metals

Hot rolled strip is either directly processed or rolled down further in the cold state. A continuous mill is used for a high production and a simple reversing mill for a low production figure. High slab weights are also possible in the latter but final thickness is not quite as thin as in a continuous mill, because of the smaller number of passes available within a given rolling time. Two-high reversing mills can roll strip down to a gauge of about $^{5}/_{32}$ in. When adding one or more finishing stands, an even smaller thickness can be attained for hot rolled strip, or a higher production figure at the same final thickness. In this way, the characteristics of a semi-continuous strip mill are approached.

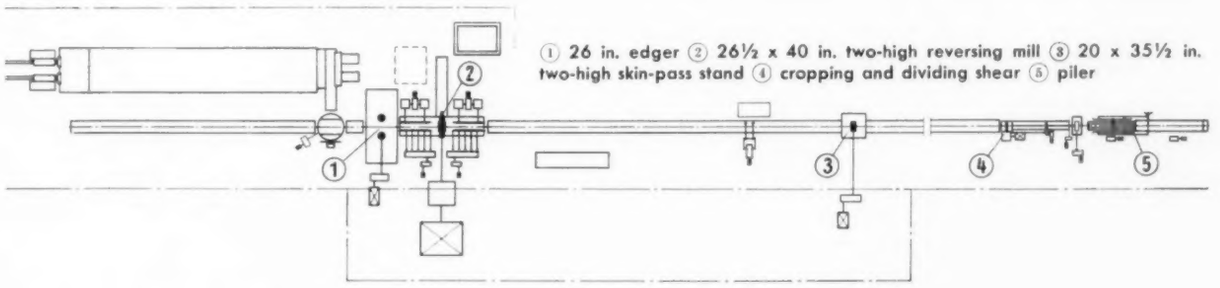
Below, two typical examples are shown from a number of reversing strip mills built by SCHLOEMANN during recent years.

Rolling mill for carbon and alloy steels

Slab ingots.....1,300 to 2,000 lbs

Strip
- min. thickness.....⅛ in.
- max. width.....32 in.
- max. length.....130 ft.

Note: The two-high reversing stand is fitted with a pre-set control; a tolerance within ±.004 is obtained.



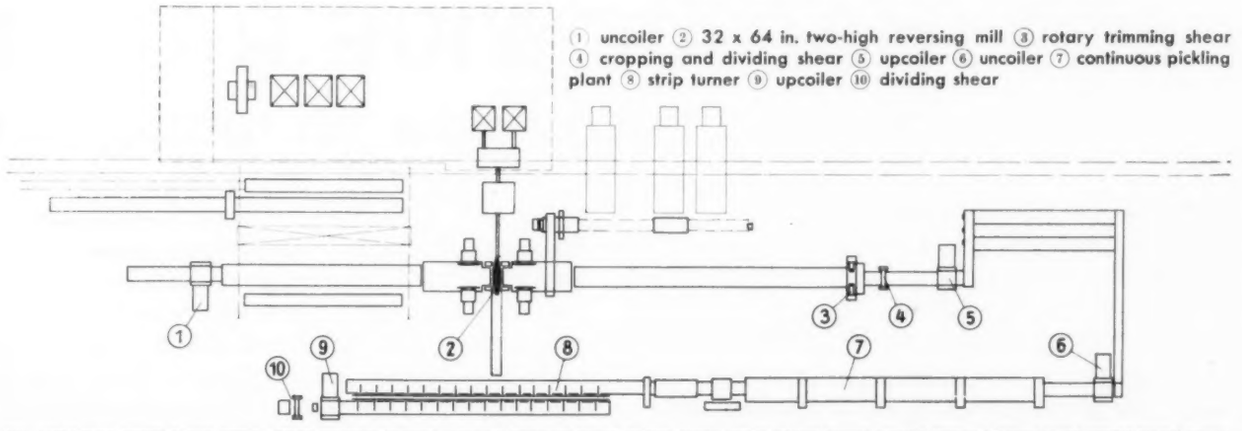
① 26 in. edger ② 26½ x 40 in. two-high reversing mill ③ 20 x 35½ in. two-high skin-pass stand ④ cropping and dividing shear ⑤ piler

Rolling mill for Al and Cu and their alloys

Cogged slabs
- max. Al.....1,100 lbs
- max. Cu.....2,200 lbs

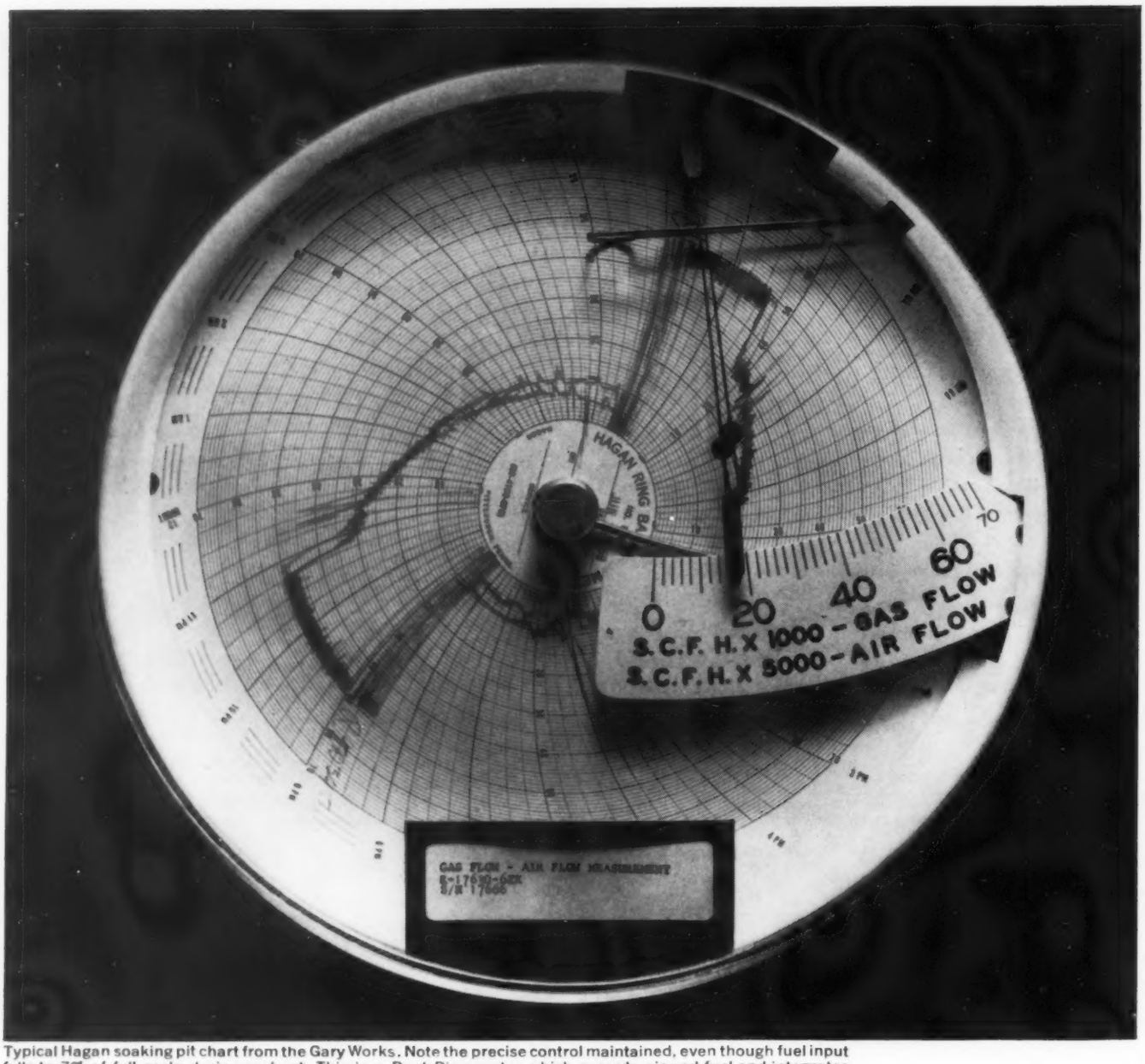
Strip
- min. thickness.....hot rolled $^{3}/_{16}$ in.
- min. thickness.....cold rolled $^{3}/_{32}$ in.
- max. width.....47 in.
- max. length.....100 ft.

Note: In the first stage of construction, the stand is being used for hot and cold rolling. Special mechanical cleaning devices permit quick change-over from copper to aluminum rolling, without the danger of contact corrosion arising. In the second stage, it is planned to erect a separate cold rolling mill.



① uncoiler ② 32 x 64 in. two-high reversing mill ③ rotary trimming shear ④ cropping and dividing shear ⑤ upcoiler ⑥ uncoiler ⑦ continuous pickling plant ⑧ strip turner ⑨ upcoiler ⑩ dividing shear

FELLER ENGINEERING CO., 1161 EMPIRE BUILDING, PITTSBURGH 22, PA.



Typical Hagan soaking pit chart from the Gary Works. Note the precise control maintained, even though fuel input falls to 7% of full scale during soakout. This is a Dual Ring meter which records air and fuel and integrates fuel. Notice how excess air is automatically programmed at low firing rates to maintain good circulation.

at Gary Work's 48 new pits . . .

HAGAN WIDE RANGE

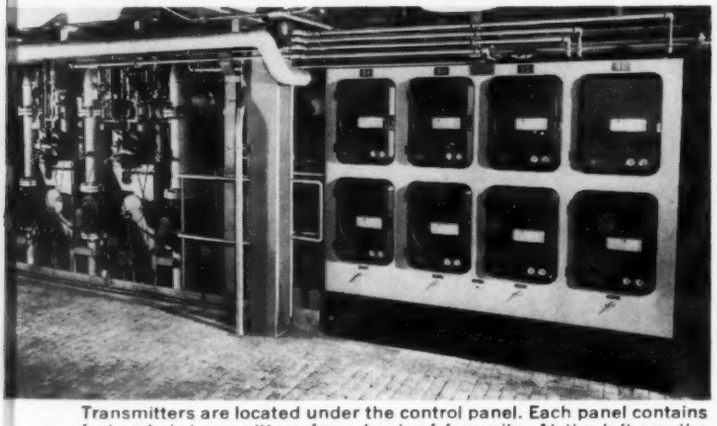
maintains optimum pit atmosphere

The ability of the Hagan Ring Balance meter to maintain high accuracy down to 6 to 8% of full scale is the main reason for the performance of the fuel-air ratio control system on 48 new dual-fuel pits at United States Steel Corporation's Gary Works.

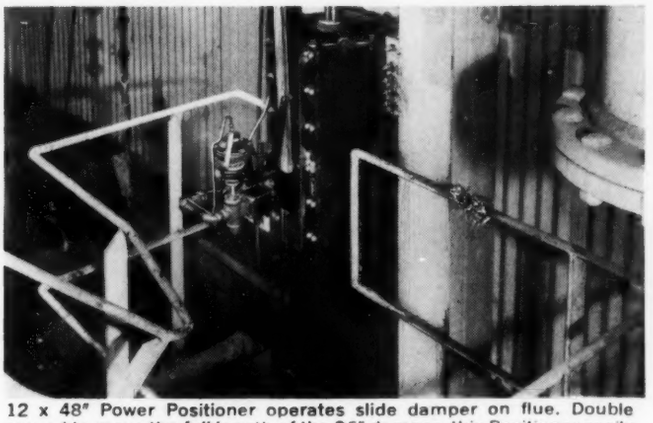
Pit atmosphere conditions are held throughout the soaking cycle at the correct point to produce optimum scale, and full advantage is taken of the fuel economies made possible by modern pit design. In addition to fuel-air ratio, Hagan controls include flue pressure and combustion air pressure. Ring Balance meters are used for both transmitting and recording, and control panels are also Hagan.

These systems were supplied as a complete package. Control panels had all equipment installed, piped and pre-calibrated, so that installation consisted of connecting up impulse lines, and making minor adjustments. As a consequence, the new Gary

General view of surface pits. Control panels are housed above pit level, with the transmitters directly below.



Transmitters are located under the control panel. Each panel contains fuel and air transmitters for a bank of four pits. At the left are the Hagan Power Positioners and Hagan V-port butterfly valves which control the flow of CO gas.



12 x 48" Power Positioner operates slide damper on flue. Double reeved to move the full length of the 96" damper, this Positioner easily handles the more than 2 ton weight. Hagan Power Positioners are available in a full range of sizes for any positioning job.

FUEL-AIR RATIO CONTROL
at all firing rates

pits were put into service with a minimum of delay.

Hagan metallurgical furnace control systems, both pneumatic and electronic, offer a degree of accuracy and reliability that contribute substantially to steel plant economy of operation. A Hagan engineer will be glad to show you how Hagan systems are helping steel producers maintain greater product uniformity and increase production. Write for new bulletin, "Hagan Soaking Pit Control Systems," MSP-177.

HAGAN CHEMICALS & CONTROLS, INC.

DIVISIONS: CALGON COMPANY, HALL LABORATORIES

HAGAN BUILDING, PITTSBURGH 30, PA.

In Canada: Hagan Corporation (Canada) Limited, Toronto

European Division: Via Flumendosa No. 13, Milano, Italy

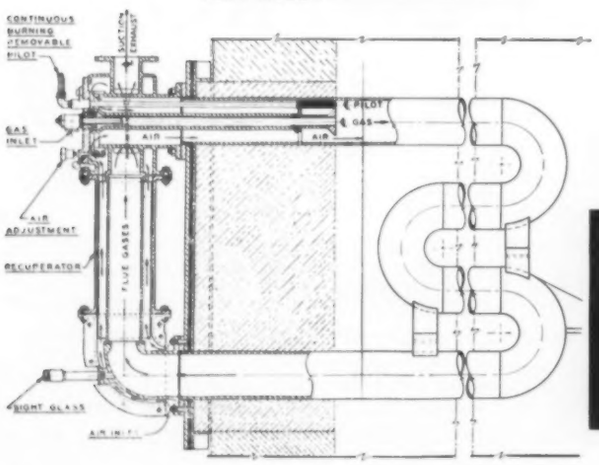
Efficient... Dependable

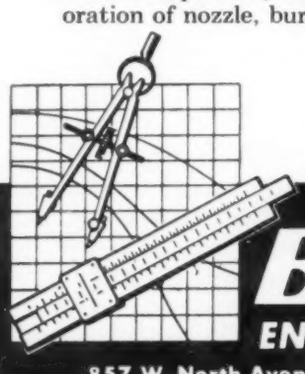
Note compact arrangement of gas inlet, flue gas exhaust, sight glass and fixed externally-lighted pilot.

The BLOOM RECUPERATIVE RADIANT TUBE BURNER

The drawing below shows how the BLOOM RADIANT TUBE BURNER can be mounted on the tube outside of the furnace, without danger of tube overheating. Nozzle is at inside edge of furnace wall. Design provides uniform tube temperature without hot spots, regardless of flow. Recuperator preheats air 600° to 800°F. Operates on clean or dirty coke oven gas, natural gas or butane. Continuously burning pilot assures positive ignition.

One installation was dismantled for inspection after a year's operation on coke oven gas, at furnace temperature of 1750°F. Conditions found were: clean nozzle, clean recuperator, clean "W" radiant tube, no deterioration of nozzle, burner parts or pilot burner.



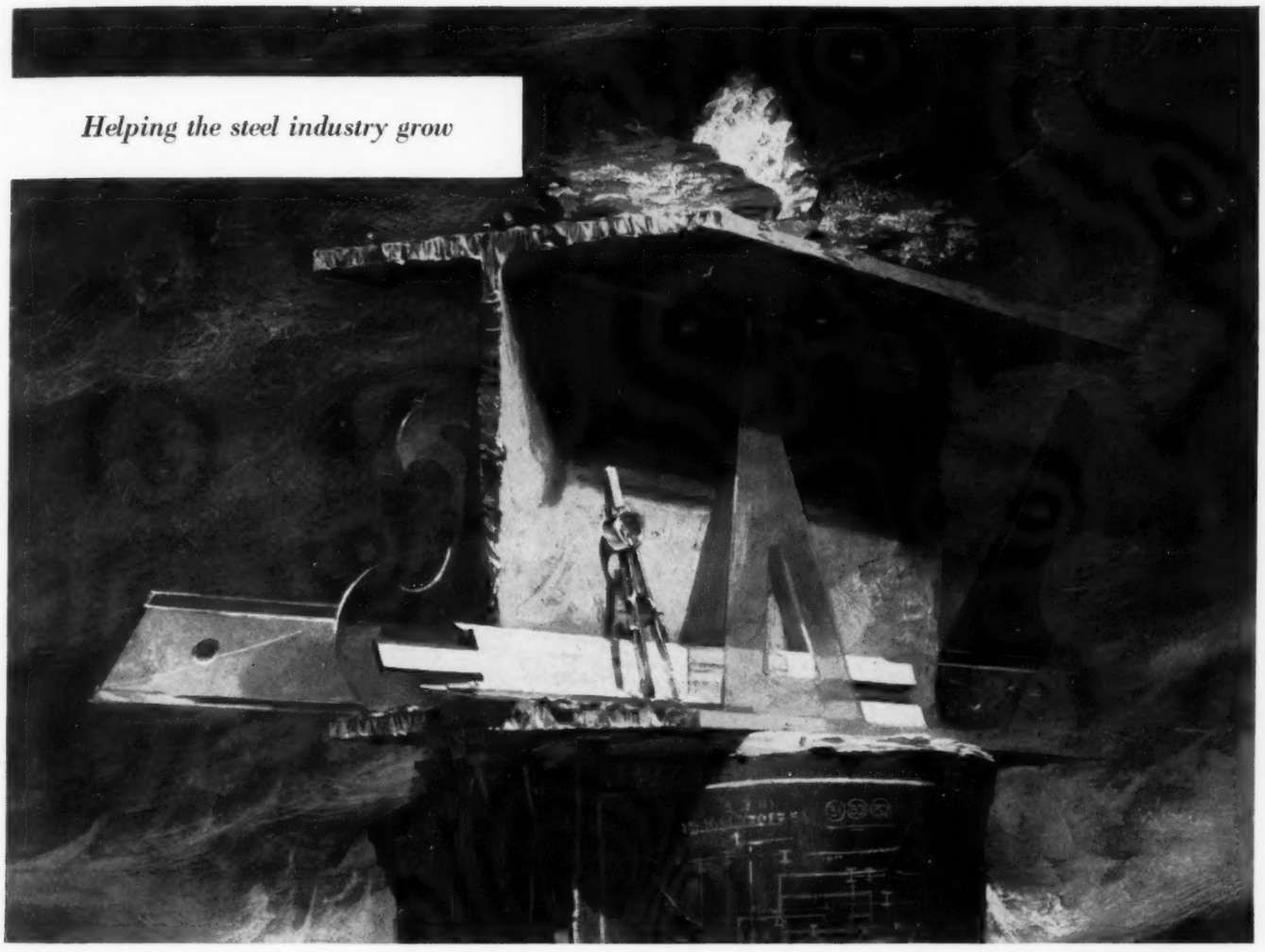


WRITE for complete details of the BLOOM RADIANT TUBE BURNER

BLOOM ENGINEERING CO., INC.

857 W. North Avenue Pittsburgh 33, Pa.

Helping the steel industry grow



The tools of the designer and the engineer, the blueprints which translate their ideas into great steel mills, the raw materials and finished steel—these are the elements of this painting in which Stanley Meltzoff dramatizes America's ever-growing steel industry.

The Economy of Experience

Operating within established budget limits in the design and construction of a steel mill, large or small, calls for experience of the highest order. Only this can effect cost and time-saving advantages—and still assure the smooth teamwork needed in design, purchasing, expediting and construction.

Making experience pay dividends to the client has been demonstrated in the design and installation of such facilities as rolling mills, slab heating furnaces, sintering strands, desulfurizer stations, oxygen plants, power plants, and coal handling equipment.

Let our skills and creativity augment the engineering facilities of your organization. Put to your service the advantages offered by United Engineers, with its background of 75 years' experience.

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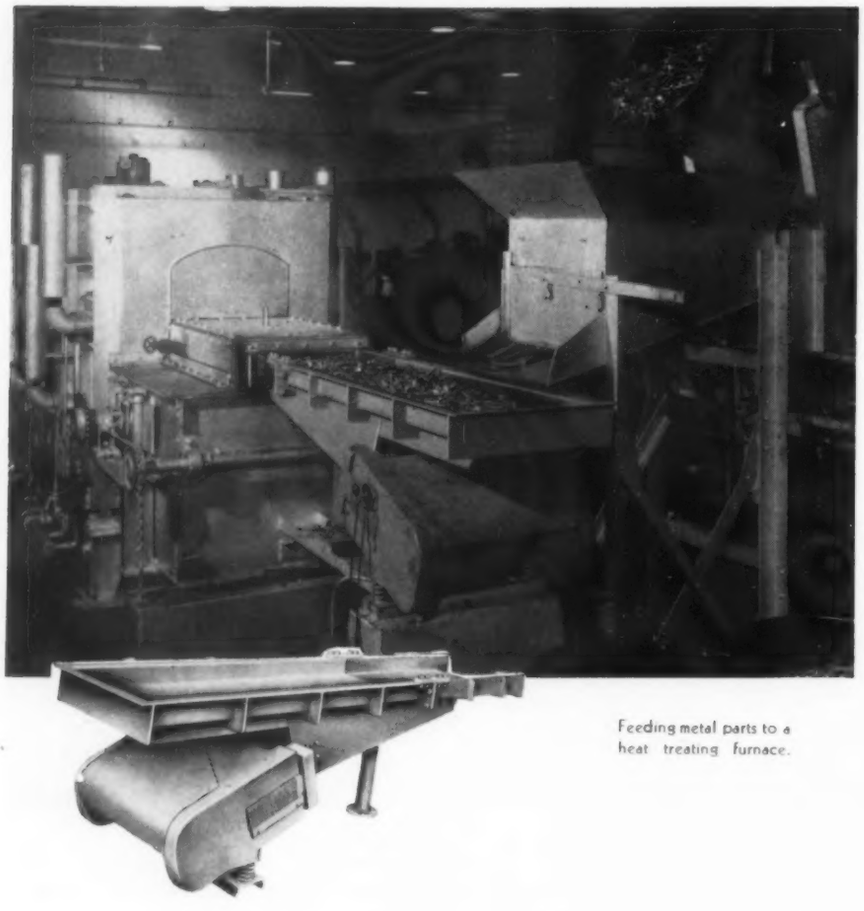
SYNTRON Vibra Flow

VIBRATORY FEEDERS

with variable control of flow rate



Feeding metal parts to a heat treating furnace.

help cut heat-treating costs!

—by providing a smooth flow of metal parts to continuous heat treating furnaces.

SYNTRON Feeders work on an electromagnetic principle that eliminates motors, gears and bearings—and assures low maintenance.

Instant control of the rate of flow of parts, to match the furnace speed.

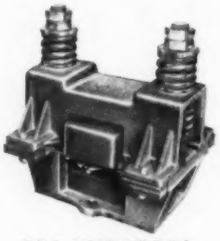
They can also be used for the controlled feeding of ores, sinter, coal, coke, mill scale, flue dust, limestone, shear scrap and other bulk materials.

Engineered and built in a wide range of sizes to meet all your bulk materials handling problems—

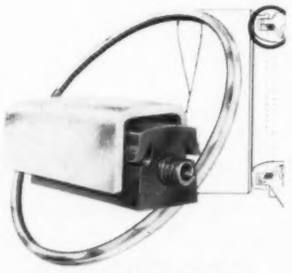
Builders of *quality* equipment for more than 30 years:

Write for catalog data—FREE

Other SYNTRON Equipment of proven dependable Quality

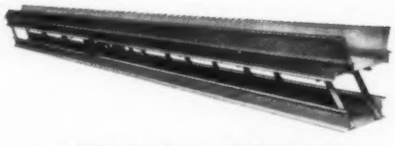


BIN VIBRATORS



ROLL NECK SEALS

VIBRATING SCREENS



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SELENIUM OR SILICON RECTIFIER POWER UNITS

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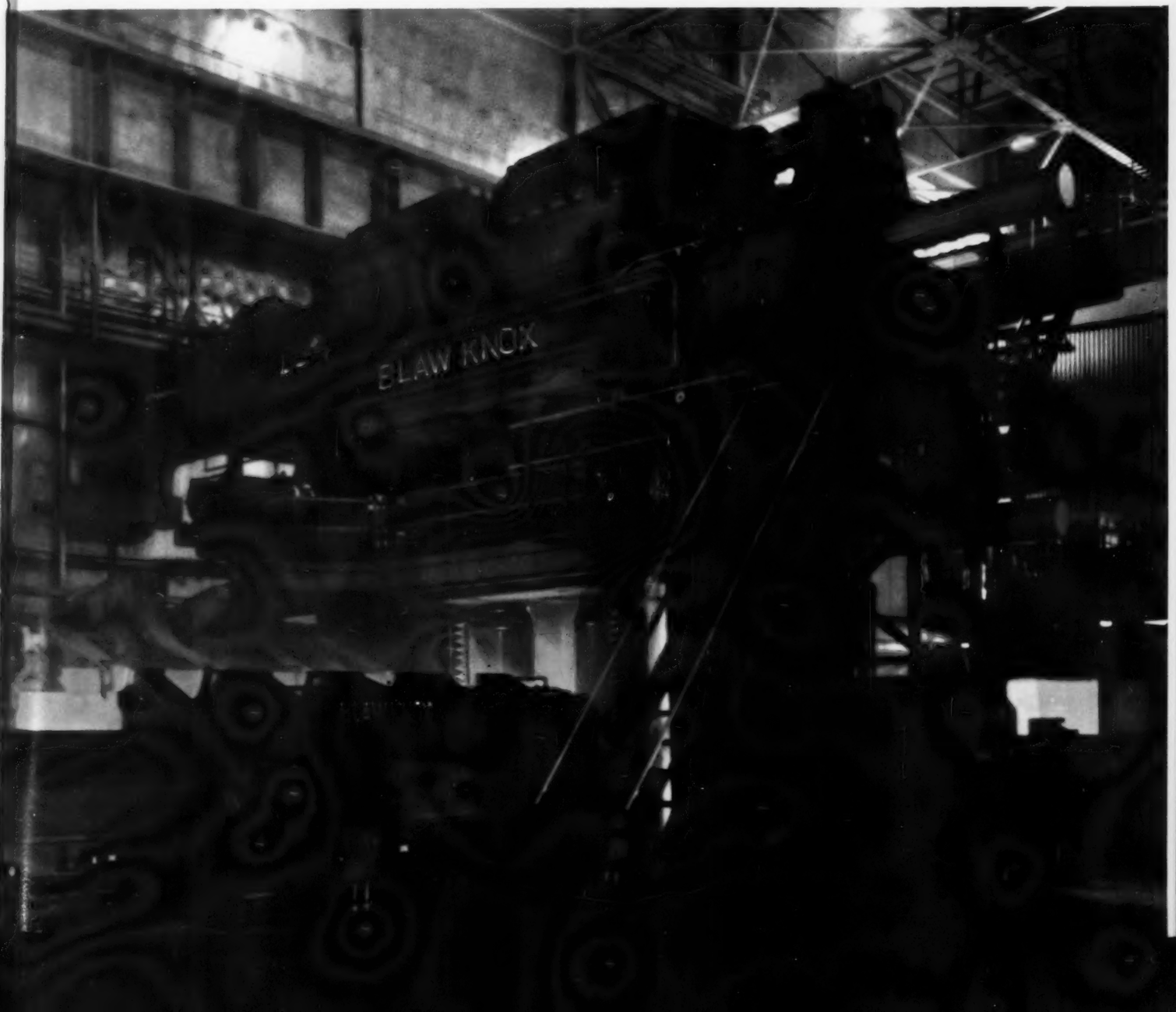
699 Lexington Avenue — Homer City, Penna.

BLAW-KNOX

engineered production equipment for the Steel Industry

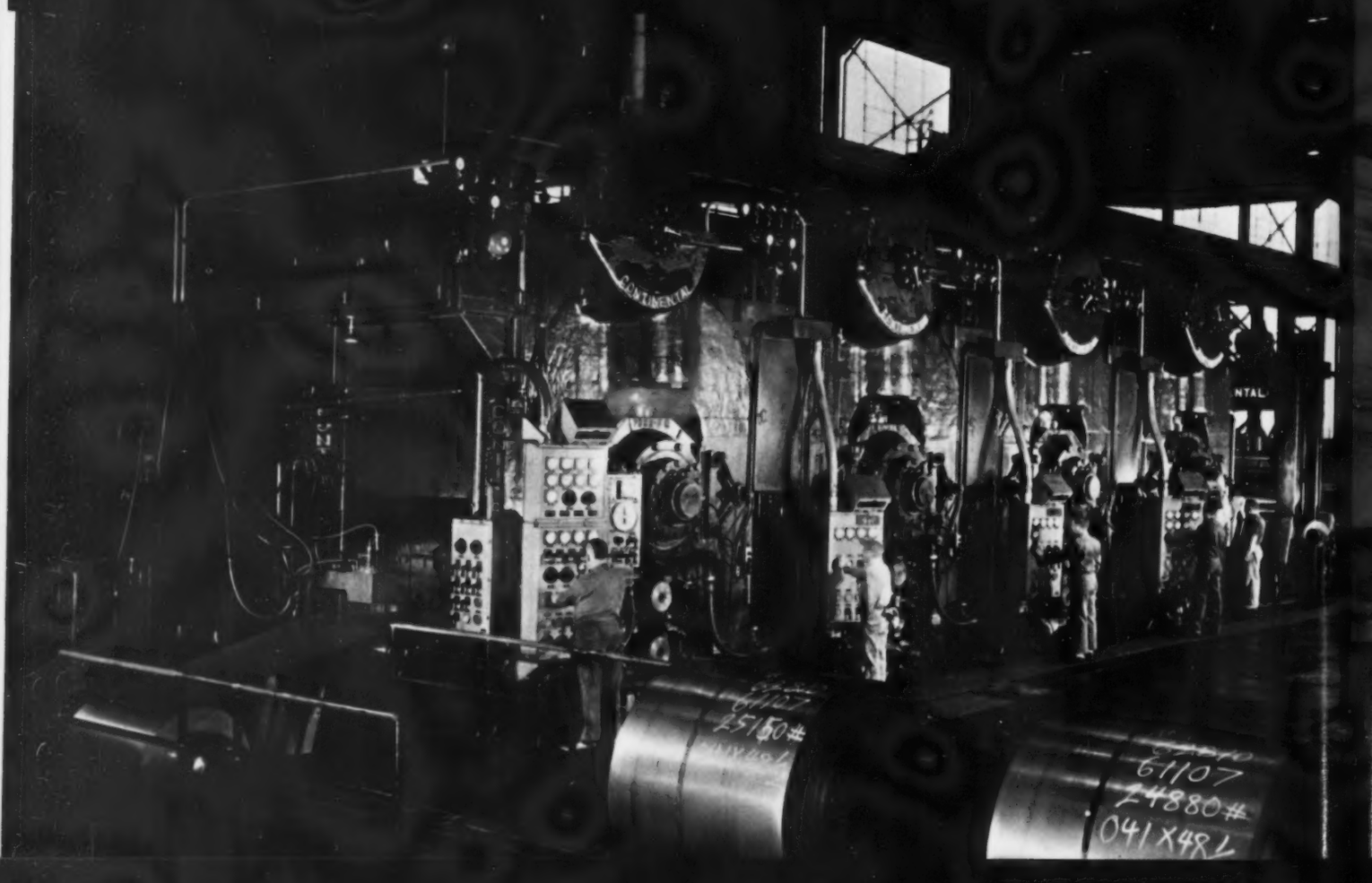
Blaw-Knox offers a complete service for the design, manufacture, and construction of steel rolling, processing, and finishing plants. In addition to these major installations, Blaw-Knox furnishes steel plants with a wide variety of products for use in operations ranging from iron making to cold finishing. The engineering force and plant capacity behind these specialized services and products are unsurpassed in the industry. They will continue to give exceptional service to the steel industry to help meet its constantly increasing production requirements.
Blaw-Knox Company • Blaw-Knox Building • 300 Sixth Avenue • Pittsburgh 22, Penna.

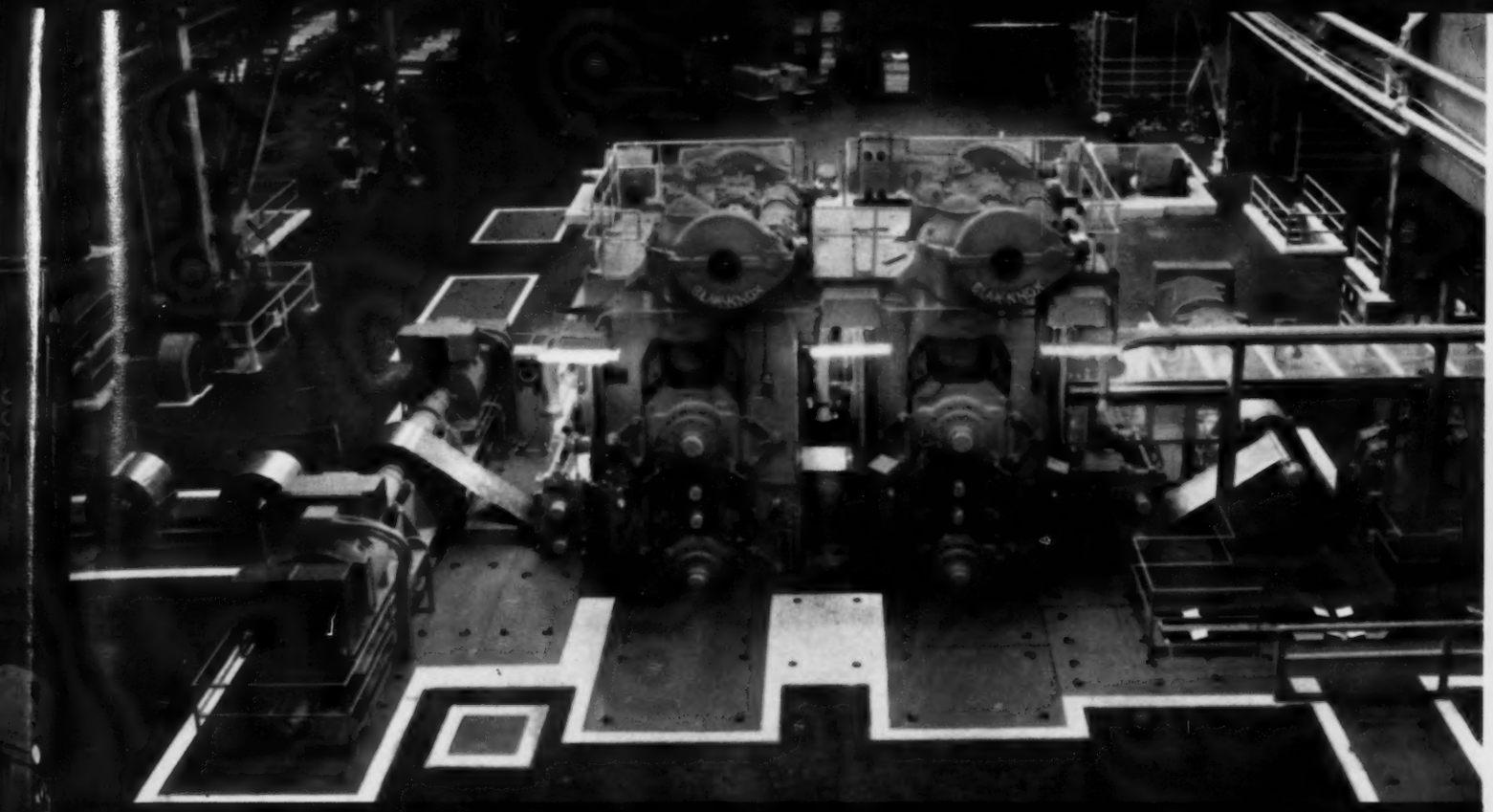
46- x 90-inch Universal Slabbing Mill



56-inch semi-continuous Hot Strip Mill

60-inch 4 stand tandem Cold Strip Mill

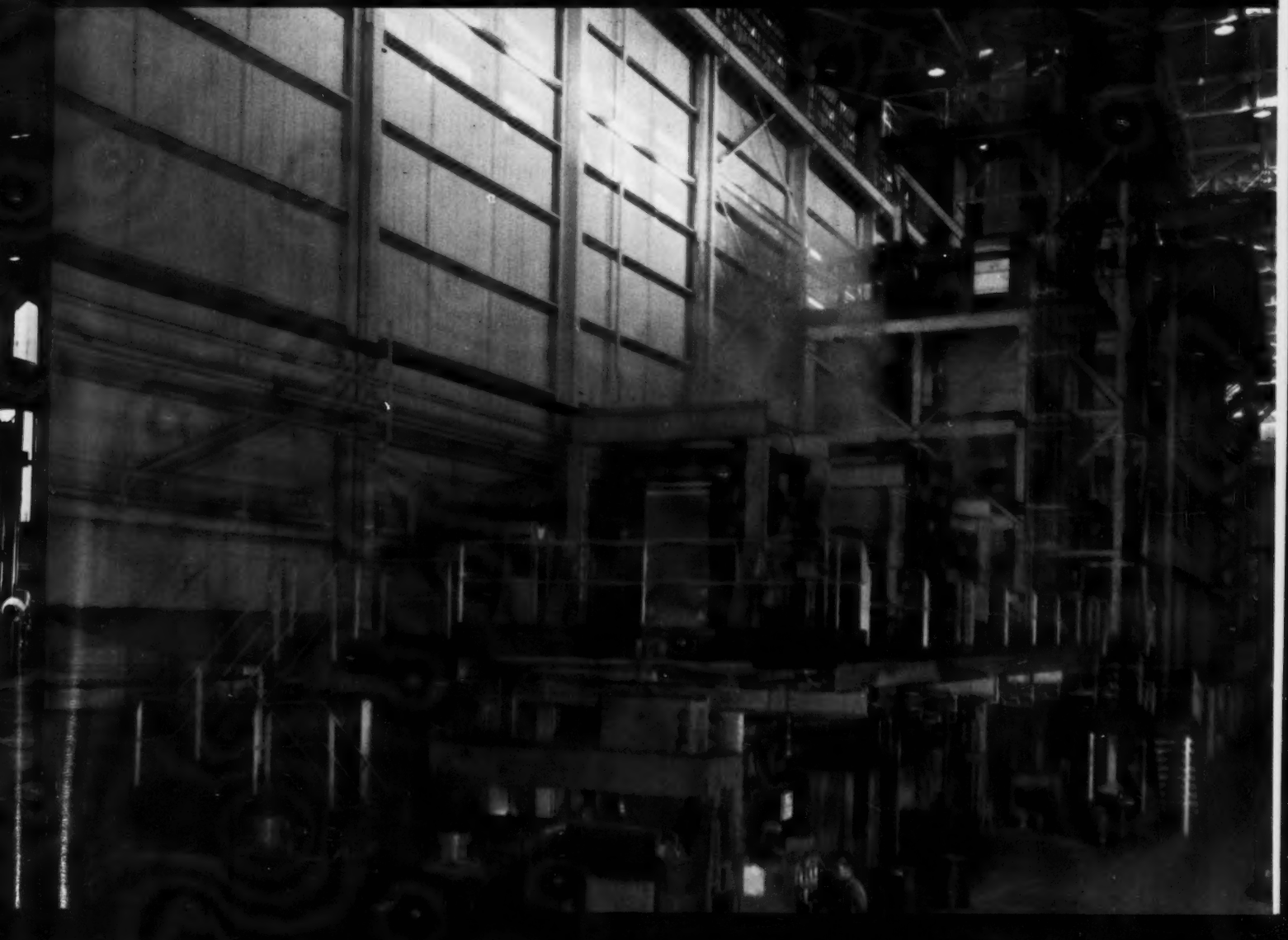


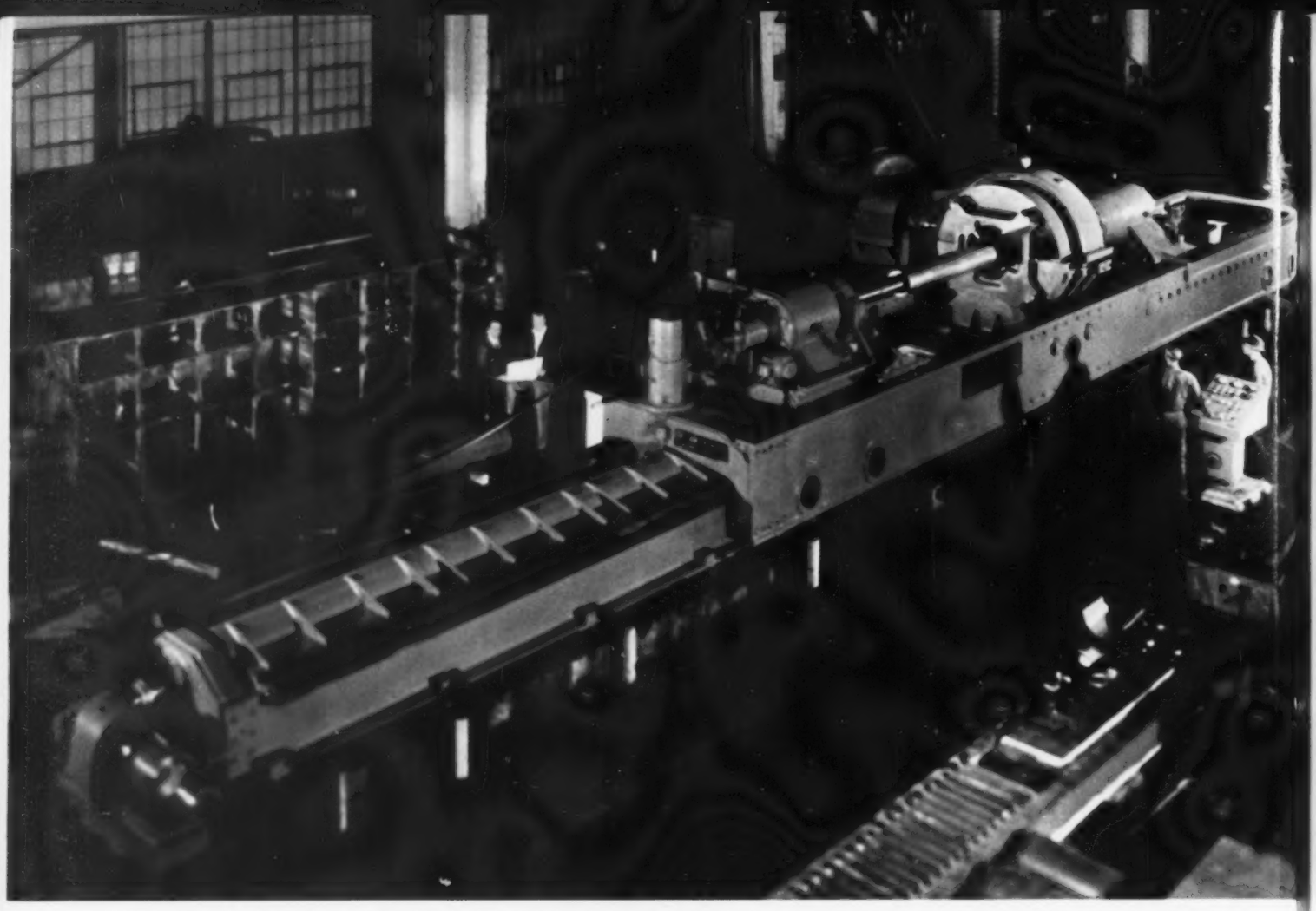


19- and 53-inch x 48-inch 2 stand Temper Mill

Aetna-Standard Continuous Annealing Line

BLAW-KNOX





Blaw-Knox Medart Tube Turner uses carbide tools for finishing heavy walled tubing from 9 to 26 inches in diameter.

Blaw-Knox Iron and Steel Foundries furnish Iron, Alloy Iron, and Steel Rolls, Carbon and Alloy Steel Castings, and heat and corrosion-resisting Alloy Castings.

Typical of Blaw-Knox mechanized Steel Plant Accessories is the Autopour® which makes possible safe, automatic teeming of ingots from remote locations on the pouring platform.

BLAW-KNOX

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ON GUARD SINCE 1888

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- METALWORKING LUBRICANTS
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Reduce Maintenance and Downtime of Mill Equipment . . .

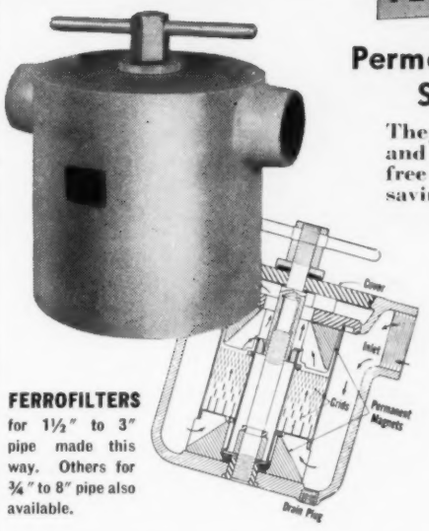
with

FERROFILTER®

Permanent Magnet Separators

They keep lubricating and hydraulic oil lines free from ferrous grit, saving wear on bearings and other parts subject to wear. FERROFILTERS help cut the cost of maintenance, downtime and replacement of equipment to the minimum.

Ask us for Bulletin PM-44



FERROFILTERS for 1½" to 3" pipe made this way. Others for ¾" to 8" pipe also available.

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Thus providing opportunities of taking advantage of special sales or the permitting of the immediate rebuilding and modernizing of machinery, whether it be one we may have in stock, or your own worn-out equipment. This will result in not only saving large sums of money but, as well, saving months of otherwise costly delay, plus all possible tax advantages.

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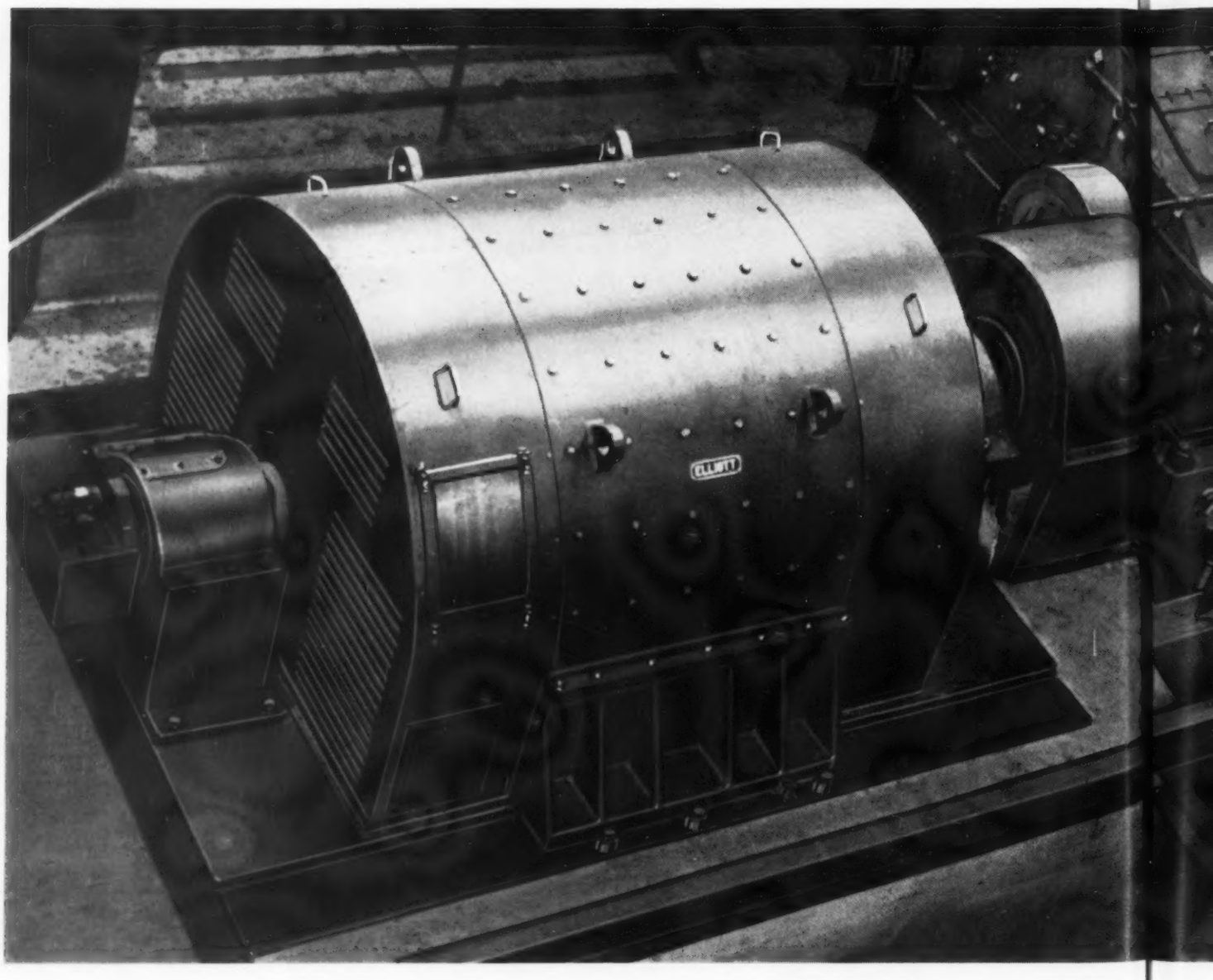
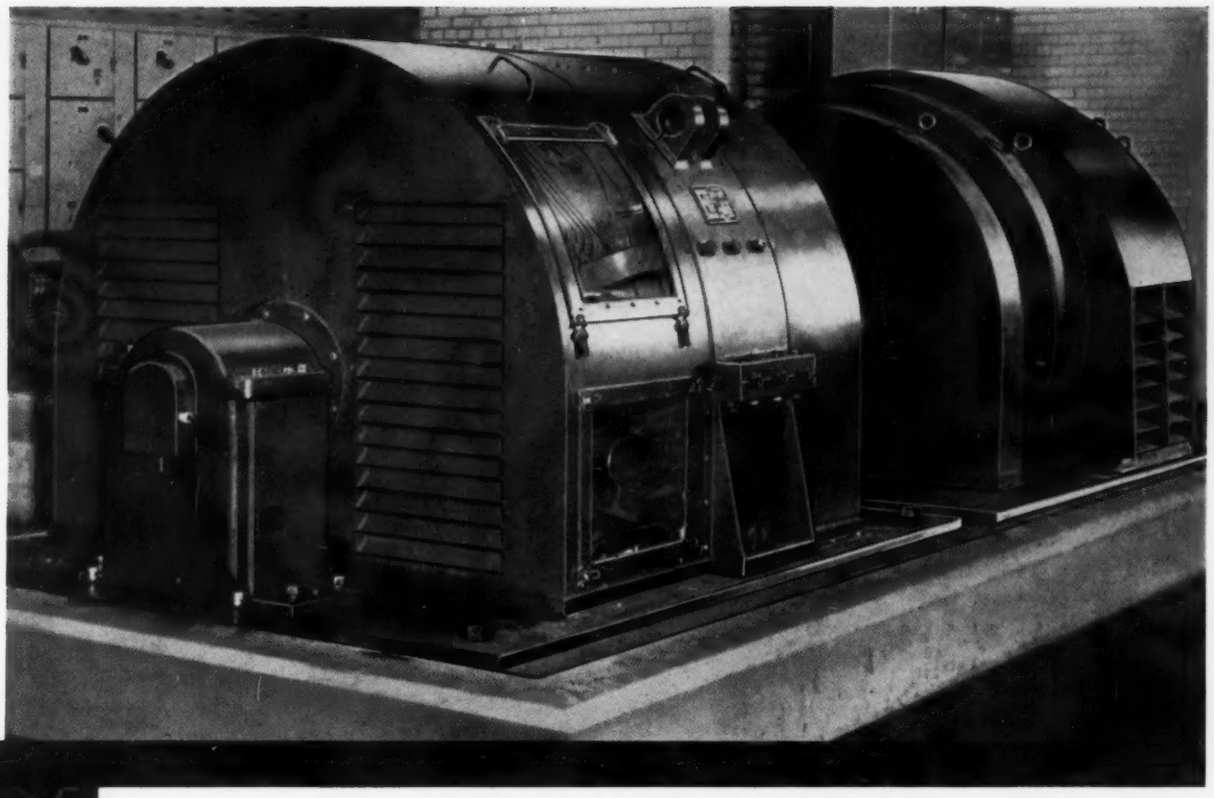
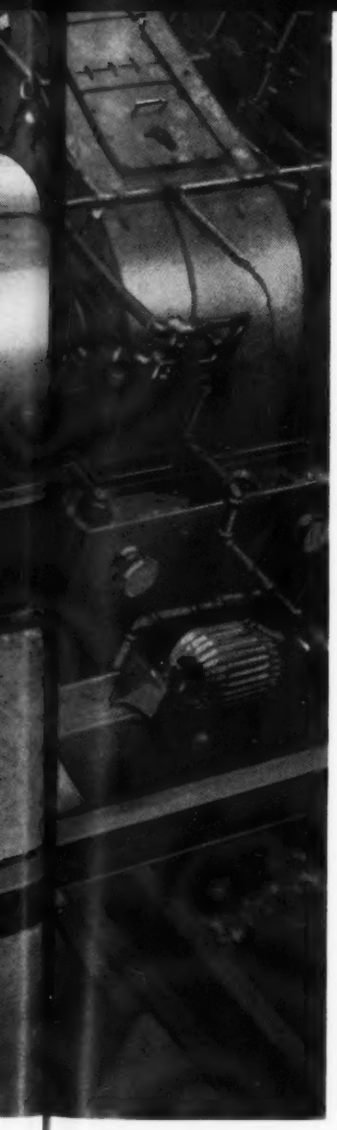
ELLIOTT EQUIPMENT powers nation's first mill FOR MECHANICALLY EXPANDING SEAMLESS TUBING

The main mill motor, seen below, is an Elliott force-ventilated 1500-hp, 80/200-rpm, 600-volt d-c motor, with low inertia and special high-torque capacity of 275 percent full load. Power for the tube-expanding motor is furnished by the Elliott motor-generator set, at the right. This two-unit force-ventilated m-g set, with peak load capacity of 275 percent, consists of a 600-volt d-c generator, driven by a 1750-hp, 13,800-volt synchronous motor. Elliott Company also furnished all the control and switchgear required.







designed and engineered to meet rigorous production requirements

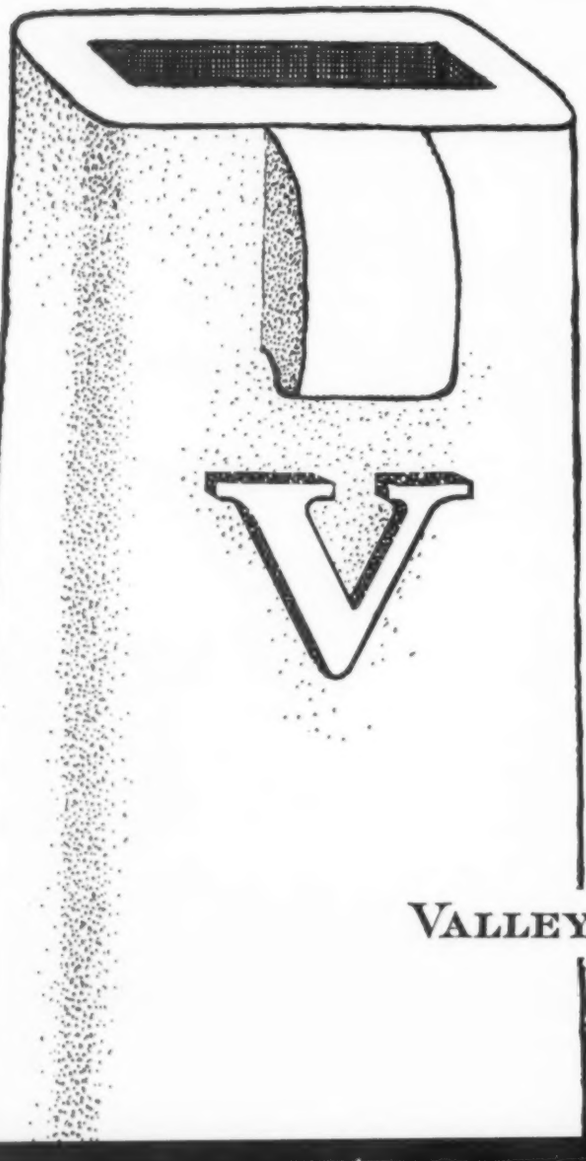
Mechanical expanding of seamless steel pipe is accomplished by forcing a water-lubricated ram and plug through the pipe with the application of 300,000 lb of pressure. The ram is driven by two heavy chains attached to a crosshead. The cold working of the metal during the expanding adds to its strength and weldability.

Elliott machines are engineered and built to keep pace with accelerated production and to meet the most severe application requirements. FABRI-STEEL construction and FABRI-SEAL winding insulation assure long, trouble-free operating life. Easy access is provided for routine inspection and maintenance. In each installation, the application of Elliott equipment is coordinated by the Elliott Company.

Bulletin Q-23A gives photographic illustrations of Elliott's range of experience as a supplier to steel and related industries. *Write Elliott Company, Ridgway Plant, Ridgway, Pa., for your copy.*

ELLIOTT Company

R9-1



Tomorrow

we'll harness the energy of the sun . . . . .

but even then

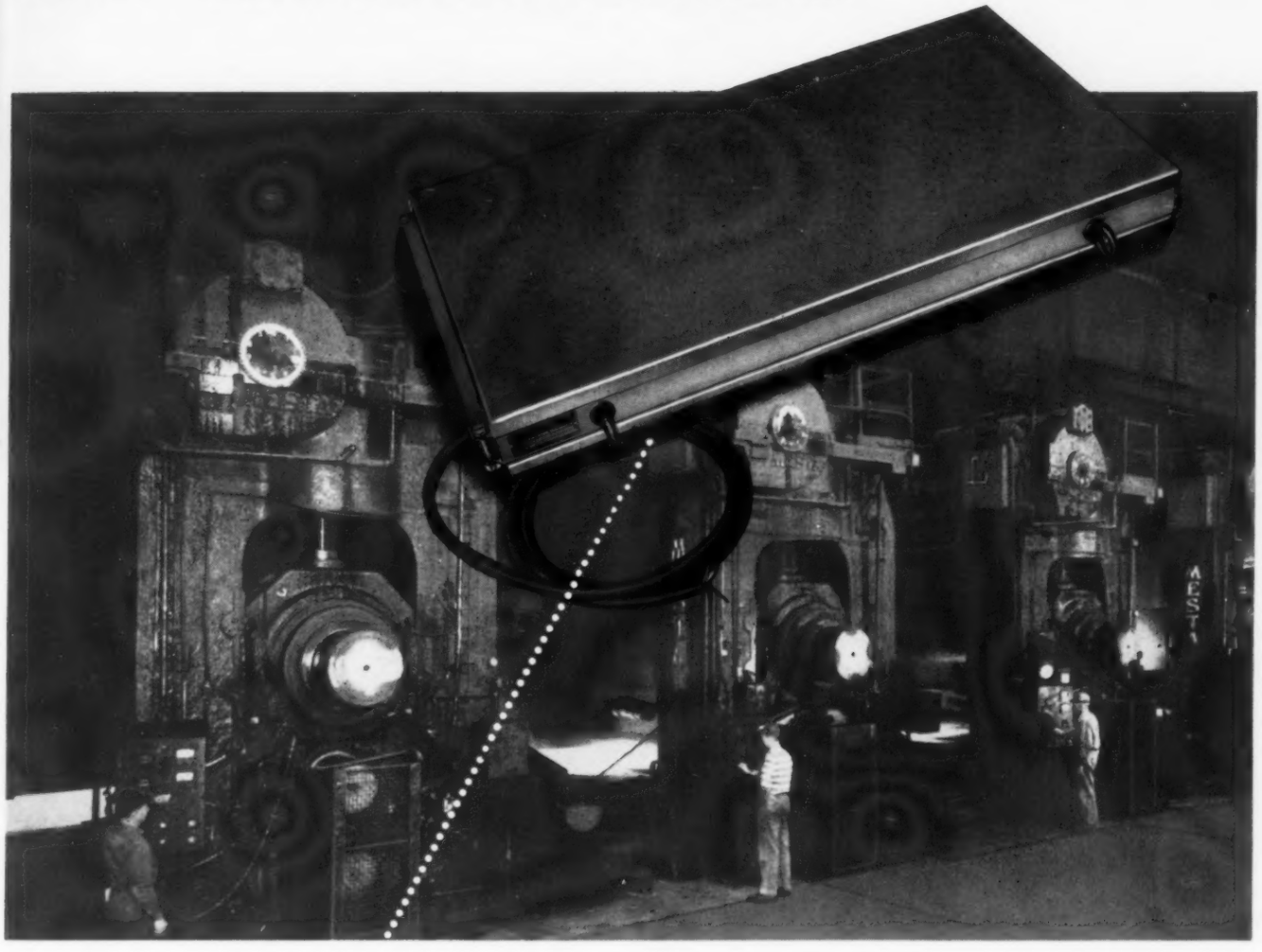
steel will be poured into

VALLEY INGOT MOULDS

VALLEY MOULD AND IRON CORPORATION

GENERAL OFFICES: Hubbard, Ohio
WESTERN OFFICE: Chicago, Illinois
NORTHERN OFFICE: Cleveland, Ohio

ASEA Pressductors are the heart of the Automatic Gage Control System for hot strip mill at Geneva Works, United States Steel Corporation, Provo, Utah.



ASEA PRESSDUCTORS are especially useful for measuring and registering the heavy roll pressures in strip mills. At Geneva Works, they have met all of the extremely heavy demands of this type of installation. Slim design permits placement under the screw or under the bottom roll.

ASEA PRESSDUCTORS have high electrical output, are not affected by temperatures and have negligible hysteresis. For a detailed description of ASEA PRESSDUCTORS and their advantages to your applications, write:

U.S. Sales and Service:

ASEA ELECTRIC, INC.
World Pioneer in Electrical Products for Industry
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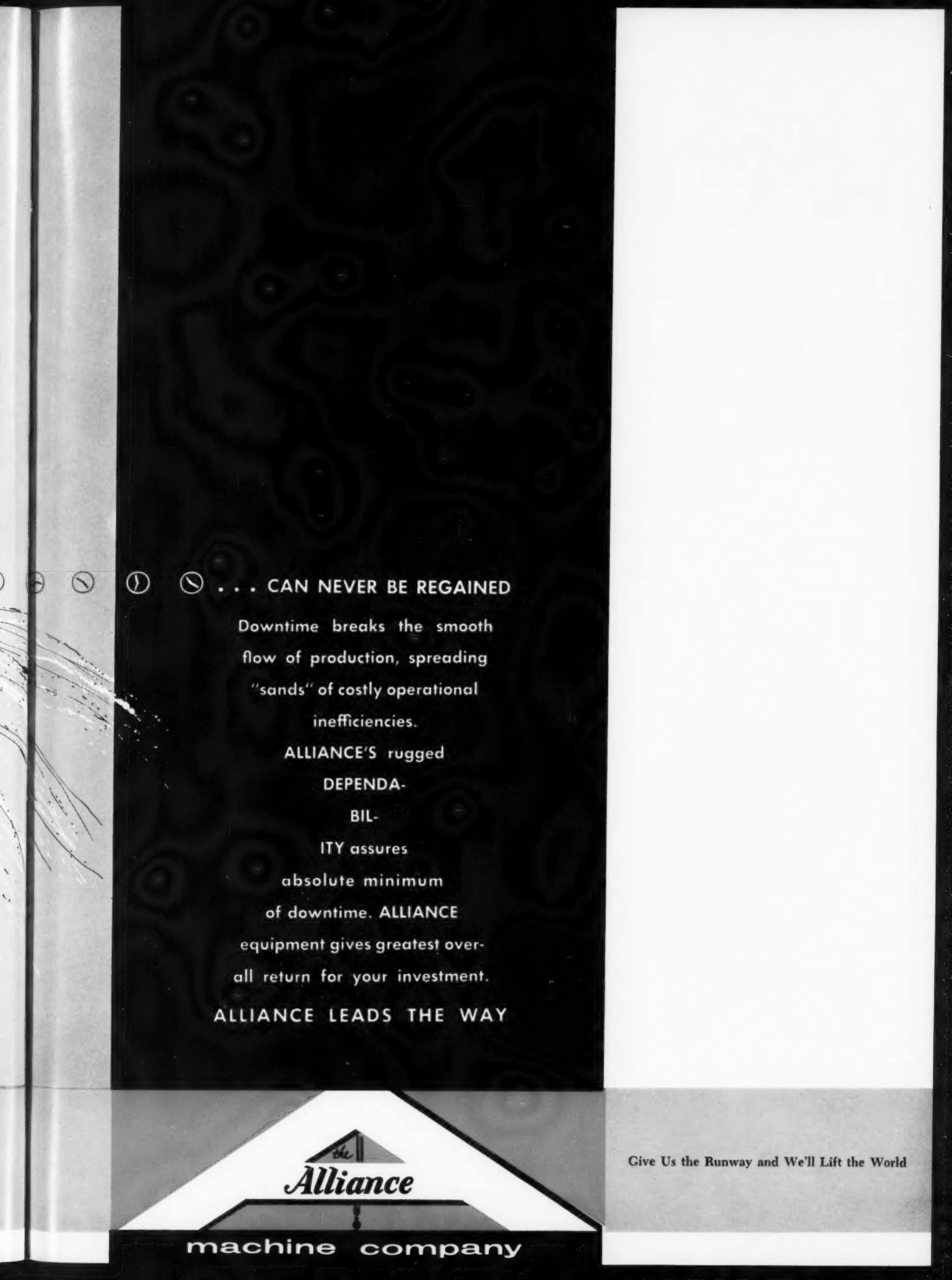

. . . CAN NEVER BE REGAINED
Downtime breaks the smooth
flow of production, spreading
"sands" of costly operational
inefficiencies.
ALLIANCE'S rugged
DEPENDA-
BIL-
ITY assures
absolute minimum
of downtime. ALLIANCE
equipment gives greatest over-
all return for your investment.
ALLIANCE LEADS THE WAY
the
Alliance
machine company
Give Us the Runway and We'll Lift the World

DE LAVAL
CENTRIFUGAL PUMPS

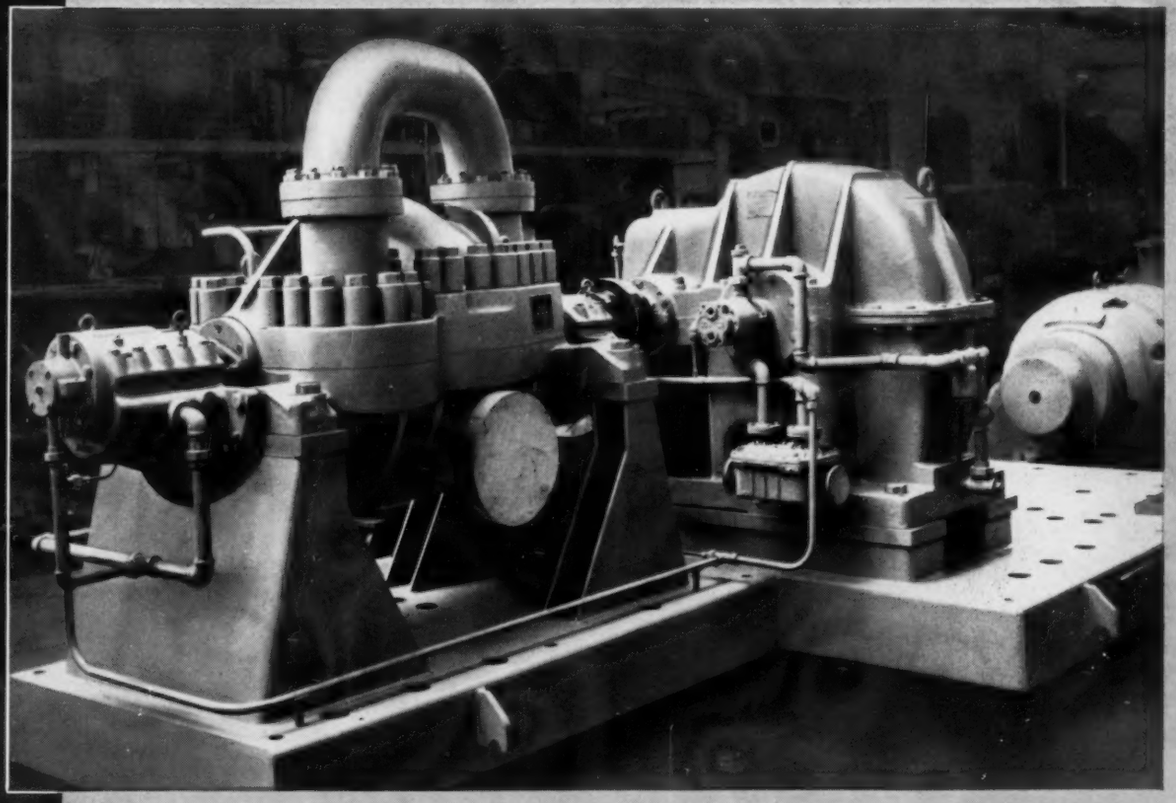
for high-pressure d

e descaling at Lukens Steel

Latest successful technique of high-pressure descaling is now being performed in this modern steelmaking facility designed by Mesta Machine Co.

The initial high-pressure descaling operation uses De Laval split-case multi-stage pumps as shown in the photograph below. Each pump supplies cold water at 1000 gpm and 1600 psig. Electric motors rated at 1750 hp drive the pumps through speed increasers which raise the speed from 1200 rpm to 4250 rpm.

De Laval pumps also serve Lukens on a 1200 psig descaling system in another section of the Coatesville, Pa. mill.



One of several arrangements available for descaling service at pressures of 1000-1200-1600 psig and capacities to 2200 gpm.

DE LAVAL *Steam Turbine Company*

870 NOTTINGHAM WAY, TRENTON 2, NEW JERSEY

SALEM-BROSIUS OFFERS YOU COMPLETE PLANT ENGINEERING SERVICE . . .

Throughout the world Salem-Brosius has expanded and diversified its service capacity to industry to an unusual degree. The company figures prominently in the engineering and erection of industrial furnaces, heavy industrial equipment and materials handling facilities.

It is a leading producer of various fabricated components of atomic reactors and aircraft engine test facilities, offers a wide line of water purifying, softening and purity testing equipment and has just introduced a system for treating and recovering waste cleaning and pickling acids.

Its line of stainless and alloy fabricated and machined parts is well known throughout the food, chemical and atomic energy industries, as is its ability to produce close tolerance machined assemblies and parts, such as stamping and forming dies for the automobile, aircraft, glass, electronic and other industries, plastic injection molding dies and dies for die castings.

Now, with expanded engineering and erection facilities, Salem-Brosius offers a complete plant engineering service. This service includes engineering and erection . . . a complete turnkey job . . . for plants, production lines or processing facilities for the steel, non-ferrous, glass and other heavy product industries.

If you are contemplating new plant capacity, expanded production facilities or revamped plant layout, it will pay you to inquire of Salem-Brosius.

A pusher-type furnace for heating stainless and alloy steel slabs for rolling. This is typical of the major industrial furnaces for which Salem-Brosius is well known.

SALEM-BROSIUS, INC.

PITTSBURGH, PENNSYLVANIA

Salem Engineering Limited, Toronto, Ontario • Salem Engineering Co., Ltd., London & Milford, England • Salem-Brosius, S.A., Luxembourg • Salem-Brosius, S.A., Paris, France • Alloy Manufacturing Corp., Pittsburgh, Pennsylvania • R. H. Freitag Manufacturing Co., Akron, Ohio • General Ionics Corp., Pittsburgh, Pennsylvania

Personnel News...

Edwin P. Boyer was elected vice president of production of John A. Roebling's Sons Corp., subsidiary of The Colorado Fuel and Iron Corp. Mr. Boyer joined Roebling in 1944 as a senior industrial engineer and served in a number of managerial and industrial planning positions before being made manufacturing manager of the cold rolled steel products division in 1954, a position he has held until his present advancement. Mr. Boyer fills the post of **William C. Ridge** who was recently elected executive vice president.

Dana B. Carleton has been named works superintendent for New Haven, Conn., Works, American Steel & Wire Division, U. S. Steel Corp., succeeding **John J. Grimes, Jr.,** who was recently appointed general superintendent for New Haven and Trenton, N. J., Works. Named to succeed Mr. Carleton as works superintendent at Trenton works is **Albert K. Zeitell. James H. Merrill** has been appointed to Mr. Zeitell's former position as division superintendent, wire mill, for South Works, Worcester, Mass.

Mr. Carleton came to Trenton Works in 1932 as a technical apprentice in the wire mill. One year later, he was named foreman—testing. He transferred to Trenton's rope mill the following year as a sub-foreman. Successive promotions there advanced him to assistant general foreman, general foreman and department superintendent, until his appointment as works superintendent at Trenton in 1952. Mr. Zeitell joined American Steel & Wire at New Haven in 1937 as an industrial engineer. He was transferred to Worcester's South Works the following year, where he served successively as turn foreman in the cable works and the wire mill, general foreman—finishing, department superintendent—finishing, and works supervisor of production planning. He was named department superintendent—round wire in 1947, and advanced to division superintendent of the wire mill in 1953. Mr. Merrill joined American Steel & Wire at South Works as a technical apprentice in the wire mill in 1942. After brief service as a junior laboratory metallurgist, he held various turn foreman positions in the round wire department. He was named a general foreman in that department in 1947, and was advanced to department superintendent in 1953.

Ford S. Thompson has been appointed director of purchases of Phoenix Steel Corp. Mr. Thompson joined Central Iron & Steel Co., now Phoenix's Plate Division, in 1929 and has worked in the Shipping, Sales and Expediting Departments. Transferred to the Purchase Department in 1948 he became assistant purchasing agent in 1949 and in 1952 became purchasing agent for the Plate Division in Harrisburg, Pa., where he will continue to make his headquarters.

James T. Bradford, Jr., has been appointed to the new position of electrical control engineer for Jones & Laughlin Steel Corp. Mr. Bradford comes to J&L from the General Electric Co., where he has served as control engineer at Roanoke, Va., since 1951.

A. Forest Wells, Jr., has been named superintendent of tin finishing and galvanizing, and **Earl Uban** assumes responsibilities as a civil engineer of Midwest Steel Corp. After a period of employment with Crown Cork and Seal Co., Mr. Wells joined the staff of Youngstown Sheet and Tube Co. for 16 years, prior to his recent appointment. Until his association with Midwest Steel, Mr. Uban was assistant professor of civil engineering at Valparaiso University.

Alexander S. Zelle has been appointed chief engineer of Bridgeport Rolling Mills Co., a subsidiary of Atlantic Coast Industries Inc. Mr. Zelle was formerly director of engineering of W. S. Rockwell Co. and works engineer of Stamford Rolling Mills Co.

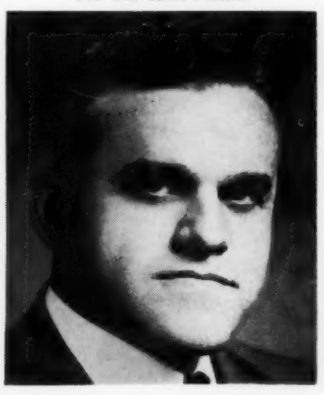
John A. Kriva has been appointed works engineer for the Ceco Steel Products Corp. Mr. Kriva comes to Ceco from the Warner Electric Brake and Clutch Co., where he was manager of manufacturing engineering.

Fred A. Brinker was named general manager, Western Division, Vanadium Corp. of America. Formerly chief metallurgist, Western Division, Mr. Brinker has

E. P. BOYER

D. B. CARLETON

A. K. ZEITELL



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Built to A. I. S. E.
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For years, Victor R. Browning & Co. has devoted major time and study to the building of heavy duty mill cranes. The finest materials and workmanship go into the construction of these cranes. All shafts are of the highest quality alloy steel. All bearings are calculated with a proper life factor as required by the A. I. S. E. We will design to suit your special requirements or build to your specifications . . . Victor R. Browning & Co. also makes a complete line of trolleys which can be adapted to existing bridges.

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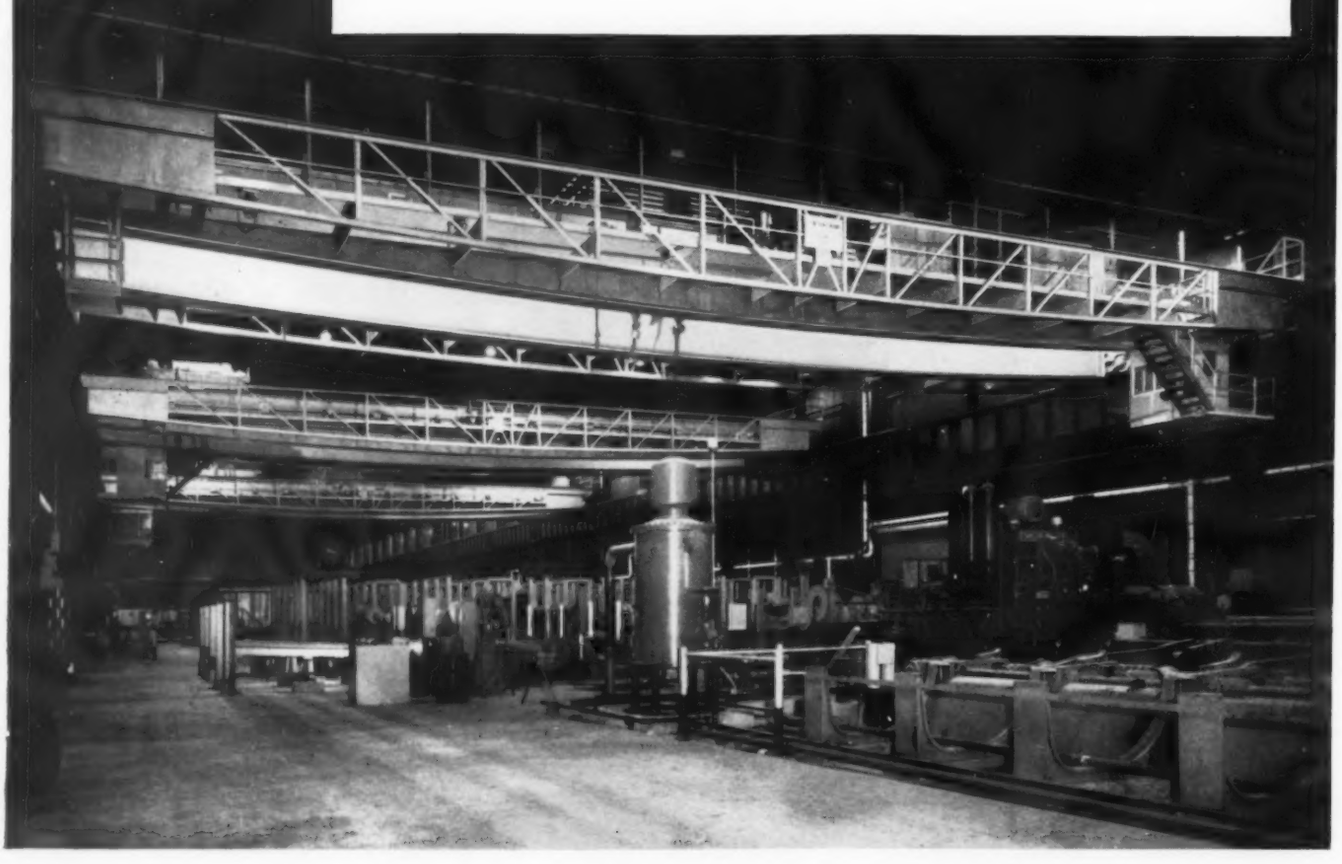
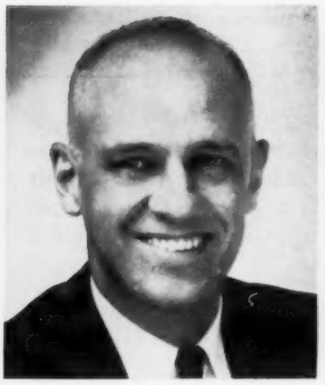


G. W. BROWN

WILLIAM RODGERS



F. A. FIELDER

R. S. POISTER

been associated with the corporation in an engineering capacity since 1951.

George W. Brown was elected president and will serve as chief executive officer of Wagner Electric Corp. He was also elected president of its subsidiary, the Wagner Brake Co., Limited of Toronto, Canada. He succeeds the late **J. H. Devor.** Mr. Brown came to Wagner as a student engineer in 1926. He served in various engineering capacities until 1937 when he was appointed personnel director. In 1952 he was promoted to executive engineer, and in 1954 was elected vice president in charge of manufacturing, engineering, purchasing and industrial relations. He was elected director of the corporation in 1956 and executive vice president in 1958.

William Rodgers has been named senior vice president of Blaw-Knox Co. Mr. Rodgers joined the company in 1953 and in the same year was named vice president and general sales manager. In his new post he will continue as general sales manager.

Frederick A. Fielder was elected as vice president and general manager of the Loewy-Hydropress Division, Baldwin-Lima-Hamilton Corp. General sales manager and assistant general manager of the division since 1955, Mr. Fielder succeeds the late **Erwin Loewy** who founded the companies that have become the Loewy-Hydropress Division.

Ralph S. Poister was named vice president of research and development, Salem-Brosius, Inc. Previously Mr. Poister had been with Crucible Steel Co. of America. He joined that firm as operating vice president in 1947 and was retired by Crucible as senior vice president in 1958. From 1936 to 1947 he had been manager of the Chicago district for Youngstown Sheet & Tube Co., and prior to that was operating vice president of Alan Wood Steel Co. At the same time, **Lowell C. Powell** was named to the position of product manager, heat treating equipment. Mr. Powell has been with Salem-Brosius since it acquired the George J. Hagan Co., in 1954, and prior to that time was district sales manager for the Hagan organization with headquarters at Ft. Wayne, Ind.

Thomas R. Watson has been appointed manager of the Washington, D. C., branch of Crane Co. He succeeds **K. D. Ackad** who resigned to become a Crane distributor at Falls Church, Va. Mr. Watson has been promoted from the post of assistant manager of the Crane Co. branch at Pittsburgh, Pa. He joined the company there in 1954 and was appointed assistant manager in 1958.

Robert J. Jacobs has been appointed general manager of the John Waldron Corp. and of its Hartig Extruder Division of Mountainside, N. J.

R. M. Heyl was named general manager, Edgewater Steel Co. At the same time **P. J. Nicholas** was named director of manufacturing control; **Leo D. Dunlap,** superintendent of manufacturing; **T. C. Tiernan,** assistant superintendent of manufacturing; **R. T. McElhose,** manager of quality control; and **C. C. Gerding,** assistant chief engineer.

Harvey N. Barrett, Jr., vice president of Basic Inc., has been placed in charge of the company's new markets development division. At the same time **Warner B. Bishop** has joined the company as vice president for sales. Mr. Barrett started with Basic Inc. in 1934 at the company's Maple Grove plant. He served as manager of refractory sales development, assistant to the president, assistant to the vice president for sales and assistant to the manager of refractory sales. In 1953 he was elected a vice president of the company. Mr. Bishop has been a vice president of Archer-Daniels-Midland Co. for the past five years, president of two A-D-M subsidiaries, Federal Foundry Supply Co. and Wyodak Chemical Co., and a director of Archer-Daniels-Midland Canada Ltd. In the newly created department under Mr. Barrett, **John P. Holt** will be in charge of refractory markets, **John A. Casey** will head the chemicals divison and **David E. Holmgren** will work on the development of refractory gunning equipment. **D. Bedell Baxter** has been

H. N. BARRETT, JR.

W. B. BISHOP

appointed manager of furnace products sales, **Charles R. Heilig and W. B. W. (Peter) Wilson** will serve under Mr. Bishop as assistant vice presidents for general sales.

Peter H. Fratangelo has been appointed chief engineer of E. W. Bliss Co.'s Mackintosh-Hemphill Division. Mr. Fratangelo came to Mackintosh-Hemphill in 1955 as chief draftsman from Pittsburgh Engineering & Machine Co. In 1956 he was appointed assistant chief engineer.

J. E. Dato was named sales manager, electric welding, Linde Co., Division of Union Carbide Corp. His previous assignment was manager—electric welding, Eastern Region. His association with the Linde Co. began with a field assignment in 1936.

Frank K. Tanner has been appointed general superintendent of the Alliance Machine Co. Mr. Tanner formerly held the position of director of quality control and has 30 years of service with Alliance.

George J. Deutsch has been appointed manager of the Chicago, Ill., district office of The Clark Controller Co. Mr. Deutsch, formerly manager of Clark's Gary, Ind., branch office, has been with the company for eight years.

Charles R. Gibbs has been appointed as director of service, Industries Group, Allis-Chalmers Manufacturing Co. He succeeds **C. B. Smith** who died July 6. **Thomas J. Hanley,** assistant manager of the service section since 1957 becomes manager, succeeding Mr. Gibbs. Mr. Gibbs has been associated with Allis-Chalmers service section since 1940. He was supervisor of mechanical equipment before being named manager of the section in 1957. Mr. Hanley was supervisor of electrical and hydraulic equipment in the service section for six years before becoming assistant manager of the section. He has been with Allis-Chalmers since 1940.

David A. Yates has been appointed manager of sales planning for the Industrial Commercial Section of General Electric Co.'s Apparatus Sales Division. Mr. Yates joined General Electric in 1930 on the company's test program. For the past 25 years, he has served in various sales and supervisory positions in General Electric motor departments.

William McNulty, Jr., was made district manager for Delta-Star Electric Div., H. K. Porter Co., Inc.'s new district sales office in Syracuse, N. Y. His previous position was as manager of the Graybar Electric Co., Inc., in Syracuse. **Gerald E. Martin** has been appointed product sales manager of industrial products at the Division's Electric Service Works in Philadelphia, Pa. **Arthur D. Sangdahl** was made district manager in the Milwaukee, Wis., sales office, and **Charles E. Pigue** was appointed product sales manager of switches and substations in the Chicago, Ill., office.

J. J. Curry has been named Midwest regional sales manager by Yale Materials Handling Division, The Yale & Towne Manufacturing Co.

George F. Placier, Jr., has been named assistant sales manager for the National Electric Division, H. K. Porter Co., Inc. **Raymond Huckestein** was named product manager—underfloor raceways; and **Walter H. Heer, Jr.,** product manager—busways. Mr. Placier joined National Electric as a sales representative in the company's Cincinnati office in 1950. Two years later he was transferred to Pittsburgh, Pa. as assistant industrial sales manager, and in 1954 was named product manager—underfloor raceways. Mr. Huckestein started with National Electric in 1951 on the company's service training course, and in 1956 was made assistant manager—underfloor raceways. Mr. Heer joined the company in 1953 as busway design specialist in Linden, N. J. He was formerly employed by the Westinghouse Electric Corp.

Arthur W. Fasold has been appointed assistant general sales manager of Hewitt-Robins, Inc. Mr. Fasold joined Hewitt-Robins as an estimator at the Charleston, W. Va., office, 1945. He was transferred to the company's headquarters in Stamford, Conn., in 1953 where he served first as assistant manager of commercial research and later manager of sales services.

Raymond R. Stuckey has been elected a vice president and director of L. W. Nash Co. Mr. Stuckey recently retired as secretary and general superintendent of The Alliance Machine Co.

Byron K. Hartman has been appointed executive vice president and general manager of Syntron Co., a subsidiary of Link-Belt Co. Mr. Hartman, who has been sales manager of Link-Belt's Colmar, Pa., plant, has been with the parent company since 1937. **Robert G. Bottorf** succeeds Mr. Hartman as sales manager at the Colmar plant. Mr. Bottorf has been with Link-Belt

P. H. FRATANGELO

J. E. DATO

F. K. TANNER

G. J. DEUTSCH

Save up to 60% battery power

WHEN OPERATING IN LOW SPEEDS

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New Skylift Electric Truck

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CURRENT-MISER-CONTROL

Check for yourself...you'll find that a substantial part of your battery power, while maneuvering in low speeds, is dissipated through heat loss by resistors. Now, Automatic's New Skylift Electric Model ELF equipped with Current-Miser-Control gives you the precise power you need *without waste!* It achieves low RPM ranges with up to 60% less amperage draw. Result—considerable saving in cost of battery power.

AUTOMATIC'S Model ELF Electric Truck has been designed for operation in plants and warehouses requiring a highly maneuverable and efficient industrial truck, with fast travel speed and lift speed. Example—4,000-lb. model, loaded, has a 6-MPH travel speed. Capacities: 4,000 thru 10,000 lbs.

New Cost-Saving Benefits of the CURRENT-MISER-CONTROL

- Up to 60% less current draw operating in low speeds
- Infinite number of speeds
- Lower motor operating temperatures
- Lower cost per battery
- Longer battery life
- More driving power in low speeds
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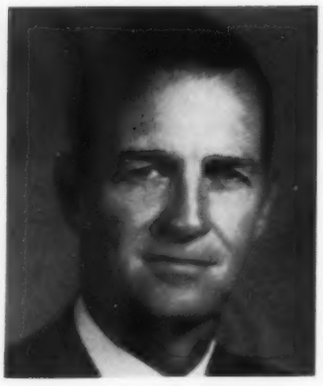
47/P9

R. E. JUST (left)

E. K. SANDBACH (center)

H. W. BUCHANAN (right)



since 1938. He has been a designer at the company's Philadelphia, Pa., plant, district sales engineer in Buffalo, N. Y., and a materials handling specialist at the Philadelphia and Colmar plants.

Ralph E. Just, former engineering supervisor in the Mill Duty Crane and Special Equipment Division of The Alliance Machine Co., has recently been appointed the company's Eastern district manager. Mr. Just served with William C. Fisher Co., and C. O. Bartlett and Snow Co., before coming to Alliance.

E. Kenneth Sandbach has been named manager, Foreign Sales Department, Engineering and Construction Division, Koppers Co., Inc. Mr. Sandbach spent 12 years in various sales and production capacities with the Chicago Bridge & Iron Co., until he joined Gahagan Dredging Co. of New York City, where he was named vice president in 1952. Prior to accepting his present position with Koppers, Mr. Sandbach was vice president of the Williams Brothers Co., Tulsa, Okla.

H. W. Buchanan has been named manager General Sales Department, Metal & Thermit Corp. Prior to his new assignment, Mr. Buchanan was sales manager for chemicals, metals and plating products for the company. He joined M&T in 1947 as a chemical engineer.

D. D. Barbor has been named manganese product manager—sales and **A. H. Barnes** has been named chromium product manager—sales, Union Carbide Metals Co., Division of Union Carbide Corp.

Alfred Cutler, who for the past eight years has been European manager of Hewitt-Robins, Inc., has been appointed manager of international operations, H. K. Porter Co., Inc.

Robert A. Wolfe, former Minneapolis-Honeywell Industrial Products Group branch industrial sales manager at Albany, N. Y., becomes manager at Pittsburgh; **Edward J. Reulbach Jr.** of the New York City branch office heads operations in Albany, and **Joseph H. Toifel** moves from Youngstown to Columbus, Ohio. **Willard T. Smith,** former branch manager at Pittsburgh, will remain in that city as an account executive specializing in instrumentation for the steel and other heavy industries.

E. F. Helminiak has been named manager of the Chicago, Ill., district, **Arthur Herbener,** manager of the Cincinnati, Ohio, district, and **F. A. Stephens,** manager of the Detroit, Mich., district, Union Carbide Metals Co., Division of Union Carbide Corp. Mr. Helminiak joined Union Carbide Metals in 1956 and served as a sales representative in the Chicago district prior to his new appointment. Mr. Herbener joined Union Carbide Metals in 1956 and served as a sales representative in the Pittsburgh district prior to his new appointment. Mr. Stephens joined Union Carbide Metals at Chicago in 1955 and prior to his new appointment served as a sales representative in the Detroit district since 1956.

Roy E. Goodwill, Jr., was appointed manager, general products division sales, central region, and **William R. Carlyon,** manager, general industrial sales, Detroit district, Allis-Chalmers Manufacturing Co. Mr. Goodwill became a sales representative in the Detroit district in 1956 and was named manager of general industrial sales there early in 1959. He has been with Allis-Chalmers since 1954. In his new position his headquarters will be in the regional office in Cleveland, Ohio. Mr. Carlyon joined Allis-Chalmers in 1949 and had been a sales representative in the Detroit district since 1951.

David B. Eden was named to the newly created position of director of distributor sales, SKF Industries, Inc. In his new capacity, Mr. Eden will be responsible for all domestic distributor sales and the operation of field warehouses. Mr. Eden began his career with SKF in 1941. Subsequently appointed quality control manager, he joined the Boston, Mass., district office as a field sales engineer in 1948. He later served as district manager at Charlotte, N. C.; Southern regional sales manager; and since 1957 he has been manager of replacement sales.

John E. Gabrielson was appointed as sales engineer in Salt Lake City, Utah, by the Bristol Co. Mr. Gabrielson has been with the company since 1956. Until his present assignment, he had been with Bristol's Application Engineering Department, at the company's home office in Waterbury, Conn.

Henry D. Hineman has been appointed to the position of field engineer with SKF Industries, Inc., Pittsburgh district sales office. He was formerly a senior regional engineer with SKF central sales region.

William H. Combs has been elected a vice president of Great Lakes Carbon Corp. Mr. Combs will continue to serve as general manager of the company's Missouri Coke and Chemical Division, with offices in St. Louis, Mo.

Harold Weiss was appointed to the newly established position of manager of applications engineering in the General Electric Co.'s Computer Department. He was formerly sales manager for computers to other General

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For resistance to side wear: Mack-Hemp *Superalloy* nickel-chrome-moly steel blooming mill rolls produce the tonnage in mills where side wear in the passes has been severe. Sets of *Superalloy* rolls have gone 900,000 tons and more to worn-out diameter!

Where firecracking is a serious problem: Mack-Hemp *Technalloy** chrome-moly steel rolls, specially heat treated, offer excellent resistance to firecracking and breakage under heavy operating conditions.

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Let us help you get exactly the right rolls for *your* blooming mills. And remember, roll service records show that *you get more tonnage from the rolls with the striped red wabblers.*

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LINDE's method for desulphurization of iron at the blast furnace is simple, efficient, and economical. Principal units are nitrogen supply, dispenser, and injection tube.

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With LINDE equipment and UNION calcium carbide, the sulphur content of molten pig iron can be effectively and economically reduced. When you use the LINDE method, you get these advantages: No noxious fumes . . . dry slag does not attack refractory materials . . . treatment is fast, easy to operate and control . . . results are predictable and uniform.

The LINDE equipment includes a large carbide dispenser, adequate nitrogen supply, and graphite injection tube. Fine mesh carbide, carried by a stream of pressurized nitrogen, is injected deep in the hot metal. Using this LINDE method, you eliminate unnecessary pigging costs. And you can gain even greater savings by buying metallurgical carbide in bulk from LINDE.

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Electric departments. Mr. Weiss joined General Electric in Syracuse, N. Y., in 1951 and has since served in various capacities in engineering, computer programming and systems analysis. He was named manager of application studies for the Computer Department in 1957, and a year later was named manager of internal sales, which position he held until his present appointment.

William F. Newbold has geen appointed director of research for the Brown Instruments Division of Minneapolis-Honeywell Regulator Co. He succeeds **Walter P. Wills**, director since 1955, who has been named technical advisor to the director of engineering, a new post. Mr. Newbold joined Brown Instruments in 1948, serving successively as a research engineer, assistant to the director of research, section head, and assistant research director. Mr. Wills has been with Brown Instruments since 1936, first as a research engineer and then as manager of research and development before becoming director of research in 1955.

John J. Sedlacek has been named manager of the Philadelphia, Pa., district sales office of I-T-E Circuit Breaker Co. Formerly district manager of I-T-E's Minneapolis, Minn., sales office, he replaces **M. L. Stoughton** who has been appointed to carry out special engineering promotion for the company's Kelman Power Circuit Breaker Division, Los Angeles, Calif. Mr. Sedlacek joined I-T-E's sales staff in 1954 and was named district manager of the newly established Minneapolis sales office in 1955.

N. W. Morelli has been appointed works manager of the Allis-Chalmers Manufacturing Co. Works in Pittsburgh, Pa., to succeed **D. G. McArn,** who will retire after 39 years of service. Mr. Morelli had been superintendent of transformer assembly at Allis-Chalmers Terre Haute, Ind., Works. He joined Allis-Chalmers in 1950, and after completing the company's training course for graduate engineers, he was assigned to the Boston Works in 1952. He served in various engineering and manufacturing capacities before being named plant engineer in 1953. In 1955 he was transferred to the Terre Haute Works as manager of plant engineering. Three years later he was appointed superintendent of transformer assembly. He also was project engineer of a program which led to expansion of the plant's transformer manufacturing facilities.

George W. Vines has been appointed as a contracting engineer by Heyl & Patterson, Inc. Mr. Vines has had 12 years of experience in the sales and engineering of heavy machinery for the steel industry.

Robert F. Moody, for the past several years, sales manager of Hyster Co.'s industrial truck division, has been appointed general sales manager of the company. With the company 12 years, Mr. Moody has held various sales promotion and sales positions. In his new post he will be responsible for general sales activities, including the operation of the sales promotion, merchandise and special products engineering departments of the company.

Herbert W. Murray was named district manager of distributor sales in the Pittsburgh territory by Parker-Hannifin Corp. Mr. Murray has had sales engineering experience with Williams and Co., and with Ritter Engineering Co., two distributing firms handling Parker products with whom he will work closely in his new assignment.

A. Lee Graham, plant superintendent of the American Forge & Manufacturing Co. for the past 11 years, has been named vice president in charge of operations. Mr. Graham was formerly with Westinghouse Air Brake Co. and the Frank Alston Co. where he later became superintendent of the Tool and Die shop.

C. W. Powell has been appointed manager, Southern district, for Metallurgical Products Department of the General Electric Co. Mr. Powell, a veteran of 23 years with the company, is a former manager of the Pittsburgh district office. He also served as a salesman in St. Louis, Cleveland and Chicago. Most recently he was assigned to the Chicago office as a sales specialist.

C. D. Ham, formerly factory sales manager, has been named manager—plans, programs, new and special products, The Okonite Co., subsidiary of Kennecott Copper Corp. **Herbert N. Bush,** formerly assistant to the vice president—marketing, has been named factory sales manager of rubber, plastic and varnished cambric cable products, replacing Mr. Ham. **Ray J. Wynne,** formerly connected with splicing materials sales, has been promoted to manager—tape department. Mr. Ham joined Okonite in 1950 as district manager of the company's Portland, Ore., sales office, was selected for the headquarters sales staff in 1954. Mr. Bush began his career in 1942 as office boy, served in the estimating, small wire and Passaic factory sales departments before his appointment as assistant to the vice president—marketing in 1953. Mr. Wynne has been associated with Okonite since 1943. Most recently he has been active in the company's sales of tapes and splicing materials.

J. B. Hodtum, manager of the central station engineering department, Allis-Chalmers Manufacturing Co.'s Pittsburgh Works, retired August 31 after more than 35 years of service. He began working for Allis-Chalmers in 1924 as a sales engineer. In 1947 he was given the position which he held until his retirement.

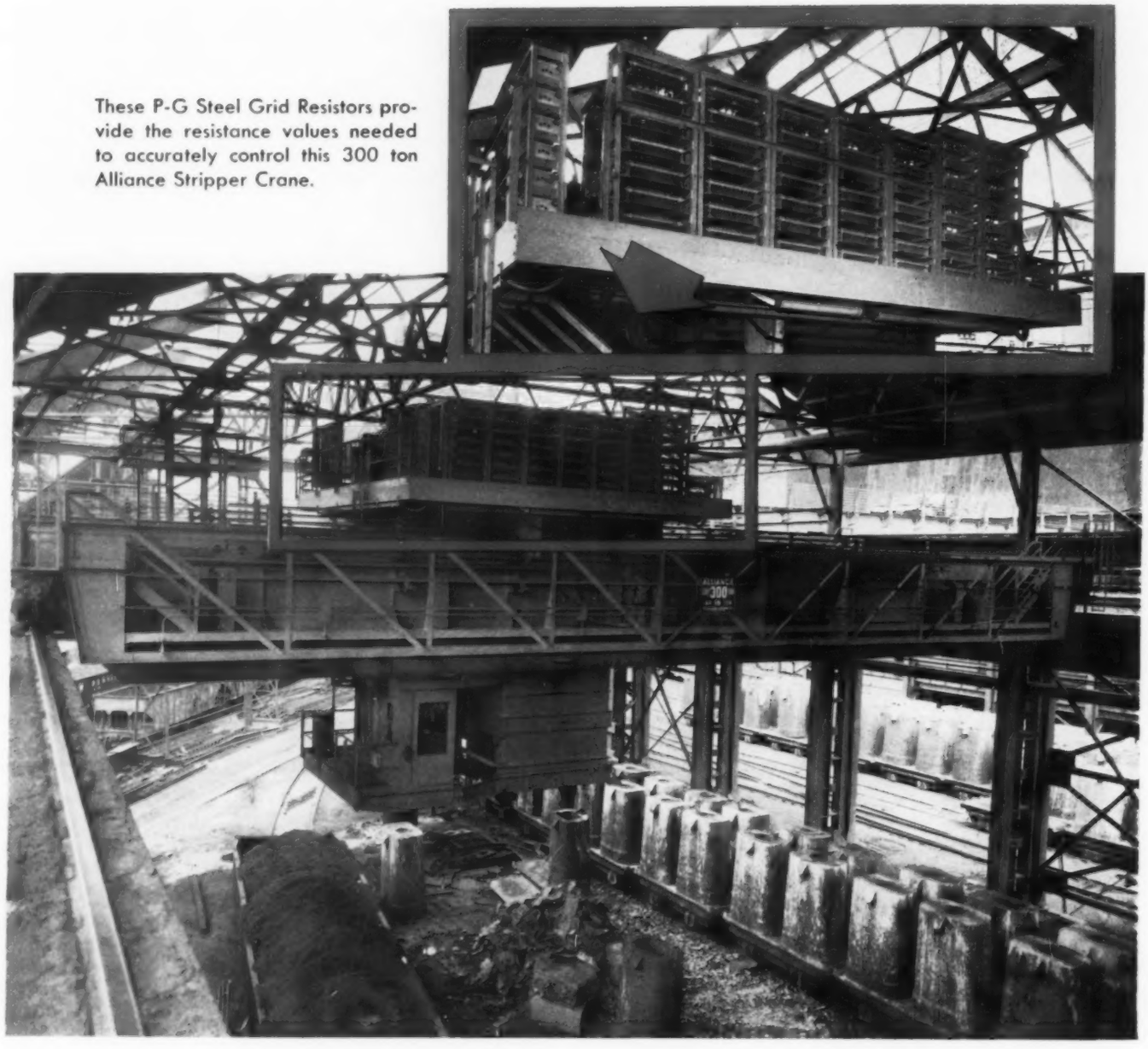
Obituaries

Erwin Loewy, founder and head of Loewy-Hydropress, and a vice president of its parent company, the Baldwin-Lima-Hamilton Corp. died July 13.

Alfred Kauffmann, a former president of Link-Belt Co. and a director for 37 years, died August 7, at the age of 79.

Russell T. Todd, 69, consulting engineer for The McKay Machine Co. died August 6.

William P. Acres, assistant to the general manager, Bethlehem Steel Co., Lebanon, Pa., died July 2.



These P-G Steel Grid Resistors provide the resistance values needed to accurately control this 300 ton Alliance Stripper Crane.

P-G Resistors constantly prove their value on this 300 ton stripper crane . . .

P-G Resistors give trouble-free service on this stripper crane at Weirton Steel Company, division of National Steel Corporation at Weirton, West Virginia.

These rugged non-breakable resistor units built of steel and mica, plus P-G exclusive design have proved their worth in various types of service for more than 20 years.

For the maximum in resistor value try P-G the ORIGINAL Steel Grid Resistor for continuous service on stripper cranes and all other steel mill applications.

Write for Bulletin No. 500

Established 1892

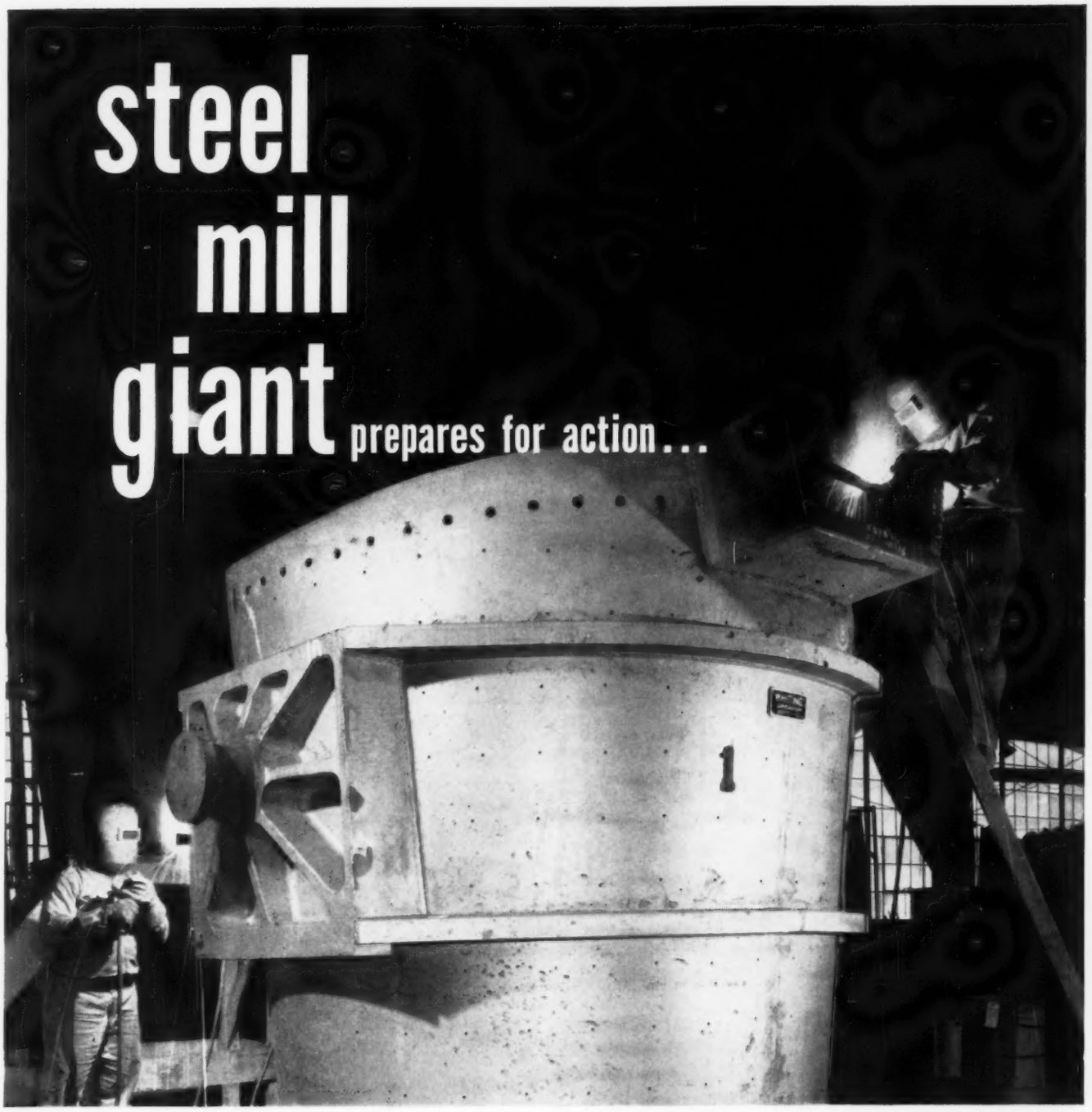
P-G

THE **POST-GLOVER** ELECTRIC COMPANY

OFFICE and FACTORY—**Kenton Lands Road, Erlanger, Kentucky**

MAILING ADDRESS—**Box 709, Covington, Kentucky**

steel mill giant prepares for action...



Preparations are nearly complete . . . and soon this giant 60-ton ladle, built to A.I.S.E. specs, will be pouring out profit for another satisfied Whiting customer. Cast steel trunion bases, forged steel trunions, and adjustable swivel-type bottom tapping lever guarantee low maintenance . . . easy control . . . long, rugged service life. When you need ladles—capacities from 100 lbs. to 200 tons—specify Whiting!

FREE CATALOG . . . Describes over 200 ladle types and sizes. Write today! *Whiting Corporation, 15655 Lathrop Avenue, Harvey, Illinois.*

75th year

LADLES

COST-SAVING EQUIPMENT . . . THE WAY TO HIGHER PROFITS

WHITING

MANUFACTURERS OF CRANES; TRAMBEAM HANDLING SYSTEMS; TRACKMOBILES; FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

News and Notes on...

Good Packing Practice

JOHNS-MANVILLE JM PRODUCTS

Maintenance and Design Hints from Johns-Manville Packings and Textiles Dept.

Subject of the month: Trouble-shooting Packing Problems

Question:

How can you pinpoint the cause of a premature failure?

If you carefully examine used packing, a correct interpretation of the damage will often suggest exactly what caused a premature failure.

Generally speaking, the reasons fall into three areas: (a) the wrong size or style packing was selected for the particular service conditions, (b) the packing was not properly installed, or (c) the equipment requires maintenance. And any of these three conditions can not only result in premature packing failure . . . but can lead to other headaches resulting from poor performance of equipment.

Let us review some of the most common types of packing failures and their causes . . . easy to recognize through a careful inspection of the damaged packing.

1. ***Damage:*** Excessive reductions in the cross-section of the packing.

Possible cause: Bearing worn, or other shaft misalignment result in eccentric movement such as shaft "whip."

2. ***Damage:*** Wearing face of the rings dried and charred, but the rest of the packing is still in good condition.

Possible Cause: Either lack of proper lubrication, or the packing was not designed to withstand speed of movement involved, or the temperature range of service encountered.

J-M #7 Centripac® Packing shown here is designed specifically for single-stage centrifugal pumps in the process industries. Speeds to 3600 rpm; temperature to 500F.

3. ***Damage:*** One or more rings missing from set.

Possible Cause: Bottom of the stuffing box is badly worn, and allows the packing to extrude into the system, causing possible contamination.

4. ***Damage:*** Wear on outside diameter of the packing.

Possible Cause: Rings rotating with the shaft, or coming loose in the box. Choosing the correct size of packing will eliminate this problem.

To solve any sealing problem, call on your local J-M Packing Distributor or Johns-Manville representative. They are equipped to help you select the right packing for the job—one that insures long, trouble-free service. For information, write to Johns-Manville, Box 14, New York 16, N.Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE

Designed to give you *Double Protection!*

WAGNER TYPE DP MOTORS

PROTECTED against corrosion...

PROTECTED against splashing liquids...

WM59-9

Wagner Type DP Motors provide *double protection* that means longer life—more versatility of application. Rugged cast iron frames and endplates are highly resistant to corrosion. Dripproof enclosures are so well designed that these motors can handle many applications that formerly required splashproof motors. These motors pack ample power into little space, are light in weight and are easy to maintain.

SLEEVE BEARING MODELS AVAILABLE. The entire line of ratings is available with ball bearing construction, or with steel-backed, babbitt-lined sleeve bearings of high load carrying capacity that provide quieter operation.

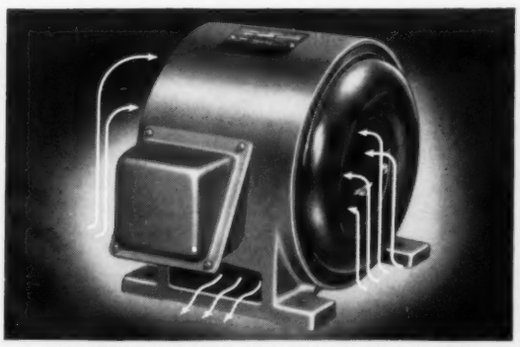
Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Wagner Bulletin MU-223.

Branches and Distributors in All Principal Cities

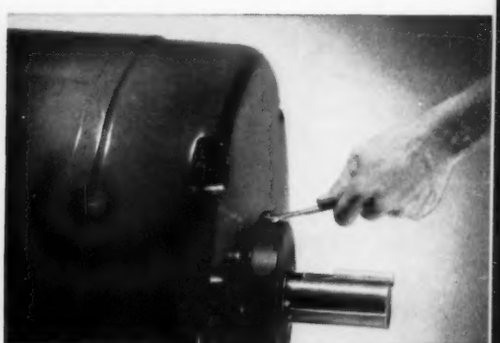
Wagner Electric Corporation

6483 Plymouth Ave. • St. Louis 14, Missouri

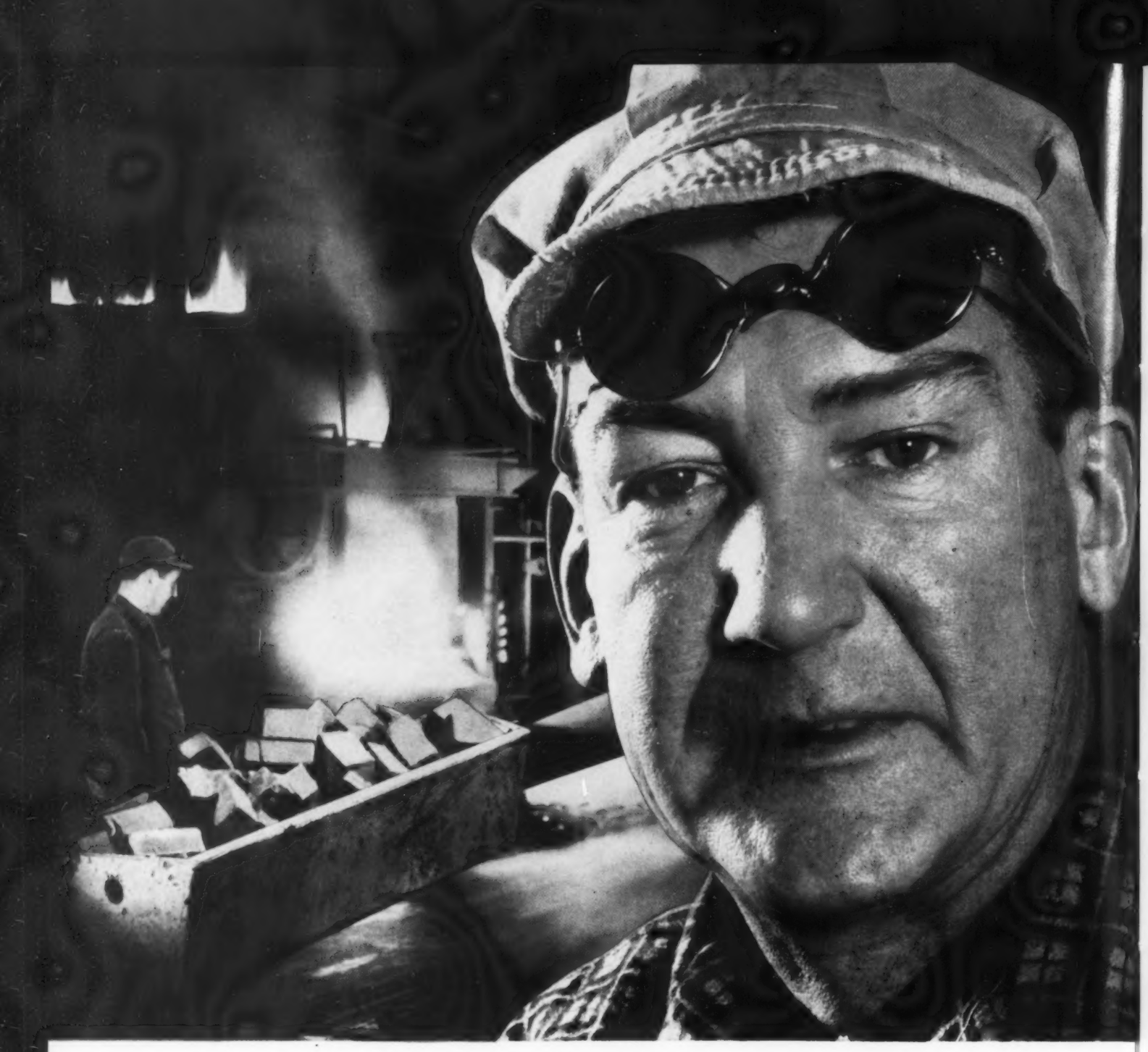
DOUBLY PROTECTED—Air intakes and outlets are positioned to provide complete protection against dripping or splashing liquids. Rugged cast iron frames protect against rough handling and corrosion.



COOLING RUNNING—Specially designed baffles, which protect the stator windings, direct a cooling stream of air through the motor to effectively cool the motor—add to motor life.



CAN BE RE-LUBRICATED—Original factory lubrication will last for years in normal service—but grease plugs are provided to permit re-lubrication that adds years to motor life under severe conditions.



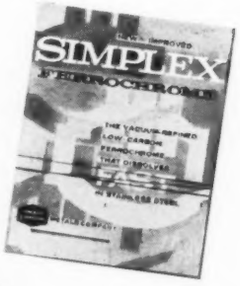
"This new SIMPLEX ferrochrome melts like butter"

The fastest dissolving low-carbon ferrochrome for stainless steel is new SIMPLEX ferrochrome. Ideal for use during slag reduction or finishing, the alloy penetrates the slag easily and provides rapid cooling of the bath. Its carbon level is so low—0.010 or 0.025 percent maximum carbon—that additions generally lower the bath carbon content. And it is one of the lowest priced low-carbon ferrochromes available.

Ask your UNION CARBIDE METALS representative for additional information about this unique new alloy.

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.
In Canada: Union Carbide Canada Limited, Toronto.

For more facts on rapid solubility, write for this new six-page SIMPLEX ferrochrome folder.



UNION CARBIDE METALS

Electromet *Brand Ferroalloys and other Metallurgical Products*

The terms "Electromet," "Simplex," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

Equipment News...

HYDRAULIC SHEAR

△ A new line of metal-cutting shears that make use of hydraulic power has been developed by the Steelweld Machinery Division of The Cleveland Crane & Engineering Co.

The shears are different from other hydraulic shears in two basic respects: (1) The blade is powered by a single hydraulic cylinder. (2) The blade is pivoted and turns in a curved path.

The single cylinder applies constant force throughout the cutting action by means of a cross shaft that links the piston rod to the two ends of the blade.

The use of one cylinder greatly simplifies the hydraulic circuit. This cylinder need only be of a size comparable with either of the two used on a two-cylinder machine. No special circuits are needed to keep the blade level, since the blade is kept level by the mechanical linkage. The number of hydraulic components is cut in half as only one system is required instead of two.

The single-cylinder design provides an important bonus advantage in that it provides a second, higher speed for lighter thicknesses. Material up to and including 65 per cent of the rated thickness is cut at double the down-stroke full-load speed. The hydraulic circuit automatically changes to slow-speed full-load capacity when required. This is a standard feature for machines with rated capacity of 6 ft x ½ in. mild steel and larger.

The pivoted-blade shearing principle overcomes serious handicaps of the guillotine-type shears. There are no slides and guides to wear out-of-true and cause inaccuracies. The upper blade operates on two heavy pivot pins secured to the end housings and travels in a circular path. The only wear to which the blade is subjected is at the pivot bearings, and this is negligible.

Knife clearance can be adjusted to suit different plate thicknesses in a few seconds by turning a hand crank conveniently located at the front of the machine. It permits shearing with exactly the right clearance for every plate size. As a result, sharp, straight, accurate cuts are obtained with minimum burr and, also, the knives stay sharp longer.

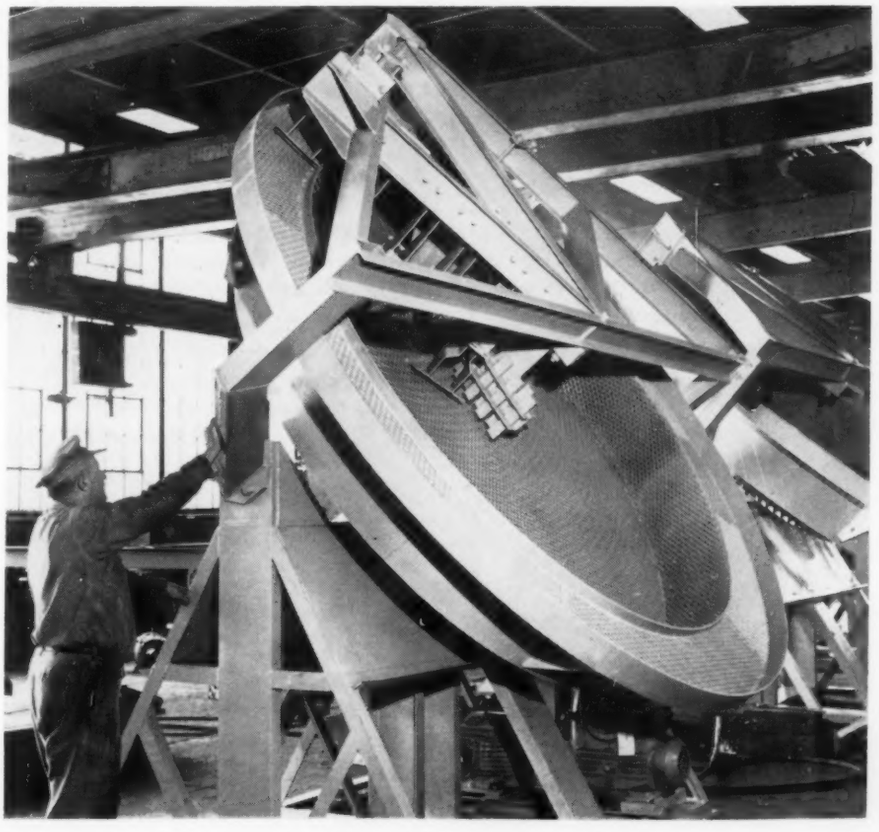
A cutting stroke adjustment is provided that enables changing the upper and lower limits of the blade travel to suit the work. The operator can quickly set the shear for short-stroke operation, thereby providing more rapid cycling when cutting narrow stock. Then the knives

PELLETIZING-MIXING DISK ANNOUNCED BY DRAVO

Production of a standard line of pelletizing-mixing disks for continuous agglomeration and mixing of a wide variety of fine granular solids has been announced by Dravo Corp. The disks will be made in four basic sizes 3-ft 3-in. diam, 8-ft 6-in. diam (shown here), 12-ft diam and 16-ft 6-in. diam. The smallest size disks will be stocked by Dravo for sale or short-term rental for use in pilot plant studies. Developed and designed by Lurgi Co. of Frankfurt, Germany and adapted to American standards, the disks are manufactured and sold in this country by Dravo under an exclusive license agreement with Lurgi. The disks are equally effective for either pelletizing or mixing. When employed for mixing, the disks are run at substantially higher speeds and thus can handle large volumes of material in relatively short times.

Experience indicates that most fine materials can be pelletized to any size from 1/16 in. to 1½ in. The disk thus affords a means of reclaiming dust, sludges and other fine material that may have been wasted in the past.

Laboratory tests and performance in actual applications indicate that the disk attains a given homogeneity of mixture with significantly less retention time than conventional batch or continuous mixers. Since retention time is readily controlled by changing the disk's speed of rotation and angle, it is possible to employ standard sized units to meet a wide variety of production requirements.



PV
PLANET VERSATILITY...

RUNOUT SYSTEM *CONTROLS*
40,000-POUND PACKS INDIVIDUALLY

Planet Corporation's 40,000-pound pack runout system, installed in a large strip mill, is built in 16 individually powered and controlled sections . . . a feature which eliminates damage to edges or corners of the sheets. The runout system starts on the pilers — two prime and one reject. One section is mounted on the platen of each. Four sections extend from each prime piler, three for storage and one for weighing. The reject piler system is the same except it has an extra section which enables the operator to run selected packs off the other side of the piler. The system can handle 40,000-pound prime packs with maximum dimensions of 200″ x 60″ x 54″.

This 40,000-pound pack runout system is more evidence of Planet's versatility . . . its ability to create and build the heaviest of material handling equipment. And like most of Planet engineered equipment, this system is designed to give the producer a better finished product as well as savings in time and labor.

PLAN WITH PLANET If you have a production, materials handling, or automation problem, let Planet demonstrate how its versatile engineering skill, and production and erection know-how can help you. Because of PV, it has paid many leading industrial concerns to "Plan with Planet" . . . it will pay you too. Write or phone today!

PLANET
CORPORATION
• ENGINEERED HANDLING SYSTEMS
• AUTOMATION EQUIPMENT
• MILL & FOUNDRY HANDLING EQUIPMENT

1816 SUNSET AVENUE
LANSING, MICHIGAN

96

will cross for only a fraction of their length, just enough to shear the stock.

Where a considerable amount of shearing is done, the limit switches can be adjusted from time to time so as to move the shearing action to different sections of the knives and thus distribute the knife wear.

Steelweld hydraulic shears are particularly suited for use by inexperienced operators. The machines cannot be damaged when trying to cut material for which they are not suited. The overload protection is uniform through the entire shearing stroke.

The shears are available in a complete range of sizes for cutting plate lengths to 30 ft and for all thicknesses from light gage to two inches.

GAS FLOW COMPUTER

△ An all-electric gas flow computer for automatically and continuously measuring the mass flow of gas under standard conditions is being marketed by the Brown Instruments division of Minneapolis-Honeywell Regulator Co.

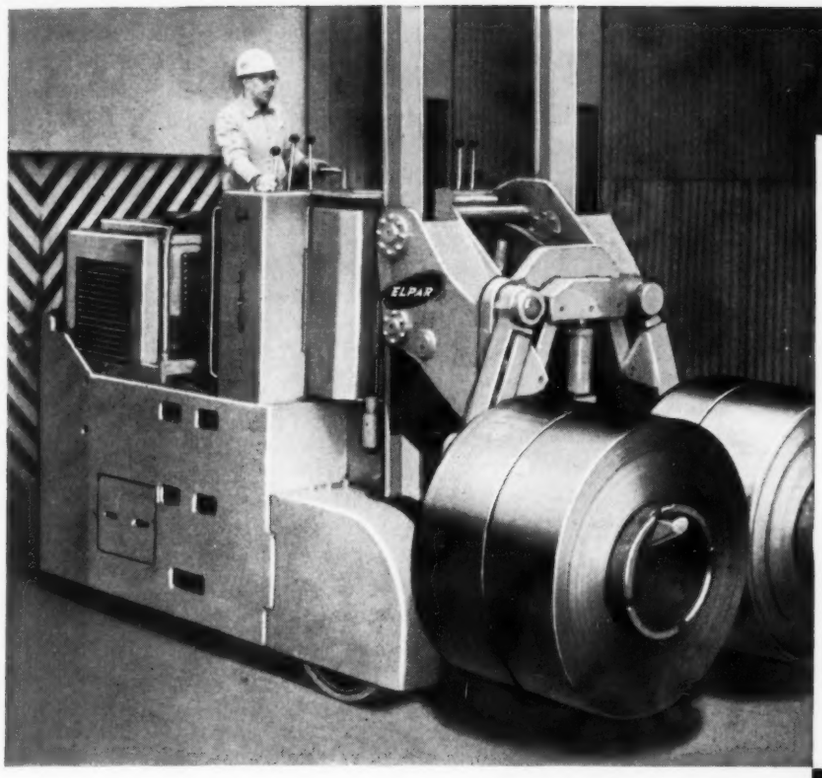
The basic system consists of a differential pressure transmitter, an absolute temperature sensing device, an absolute pressure transmitter, an analog computing circuit and an electronic circular or strip chart recorder.

In addition to such functions as indication, recording, control and integration, the gas flow computer can be coupled to telemetering and remote control systems, supervisory control, data handling and industrial process computers.

By continously correcting the flow measurement for all variables, the system provides the higher accuracy required for economic gas dispatching and accounting procedures. Daily chart changing and manual hourly flow calculations are eliminated.

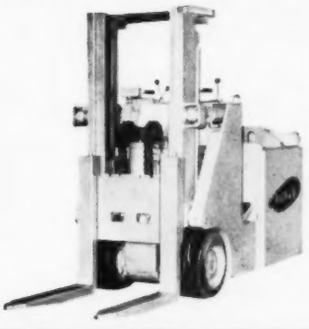
Although designed originally to meet requirements of the natural gas industry, the gas flow computer, the company said, can be applied to flow measurement in chemical, steel, petroleum refining and other industries.

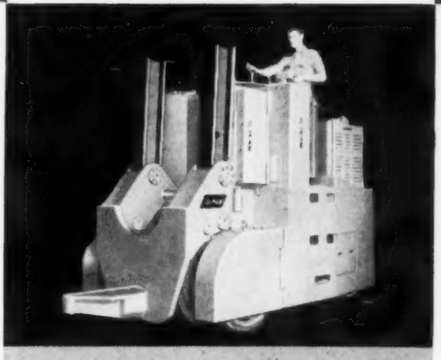
Minor rearrangements of components permits use of the computing system on either single or multiple metering installations. The



ELPAR

FORK AND RAM TRUCKS





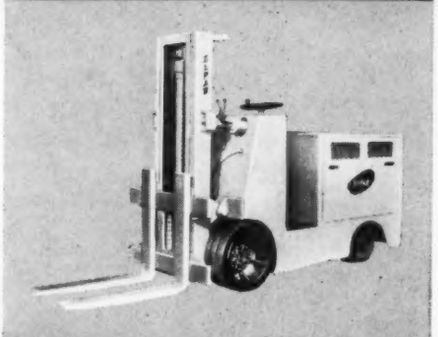
Leader In Heavy Duty Trucks For Metalworking Plants

CAPACITIES FROM 2,000 TO 100,000 LBS.

Metalworking plants — where handling is toughest — demand the kind of rugged trucks that have been an ELPAR specialty for more than 50 years.

Electric power assures dependability and low operating cost. Reduced maintenance . . . space saving economy . . . greater safety . . . easy handling . . . remarkable operating efficiency — are other essential truck features that metalworking plants demand. ELPAR trucks provide them all, plus, a complete line of trucks from the smallest narrow aisle stacker to huge steel handlers.

Ask your local ELPAR man to show you the features of cost-cutting ELPAR trucks built especially for rough service. There's sure to be one that suits your needs exactly.



WRITE FOR THIS NEW LITERATURE . . .

- New FORK TRUCK Bulletin — 2,000 to 10,000 pounds capacity.
- New R-10T Bulletin — 4,000 to 10,000 pounds capacity.
- New TITAN Bulletin — 12,000 to 25,000 pounds capacity.
- New HERCULES Bulletin — 20,000 to 100,000 pounds capacity.

ELPAR

ELECTRIC TRUCKS

THE ELWELL-PARKER ELECTRIC COMPANY
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TWICE THE LIFE . . . ONE-THIRD THE OPERATING COST

recorder is available with pneumatic or electric control, retransmitting slidewires, digital encoder, motor or servo-driven control index or pneumatic indexit, high-low alarms, auxiliary contacts, pulse telemeter transmitter and other options.

D-C RECTIFIER LINES

△ Introduction of two new lines of 250-volt d-c silicon rectifiers, one for heavy duty steel mill and industrial applications, and the other for general purpose operations has been announced by Allis-Chalmers.

The heavy duty rectifiers are available in 400, 500, 600, 750, 1000, 1500 and 2000-kw ratings with standard sizes carrying 100 per cent continuous loads, 125 per cent current loads for two hours or 200 per cent for one minute.

The new 150 to 300-kw general purpose rectifiers are designed for crane, hoist and general shop service, elevator supply, machine tools with d-c motors or control, magnetic chucks and lifting magnets, etc. The single factory-packaged units are available in ratings of 150, 200, 250 and 300 kw and for three-phase, 60-cycle primary voltages of 208, 240, 480 or 600.

The heavy duty silicon rectifier consists of incoming line, transformer, rectifier and d-c breaker sections assembled on three related bases for ready installation. The transformers are self-cooled dry type.

Use of high quality silicon diodes and high-speed current limiting fuses in series with each paralleled branch in the rectifier unit insures immediate isolation of a faulted cell without interruption of the d-c power output.

Fuse monitoring equipment flashes a warning upon failure of the first diode and helps locate the faulted cell. Since the remaining paralleled cells in the phase have sufficient capacity to carry normal loads without harm, the faulted diode can be replaced at the convenience of the operator. A second failure is a signal to the fuse monitoring system to shut down. Use of special high-speed current limiting fuses when removing a faulted cell from the circuit makes possible such a rapid clearance that power to the load is unaffected.

A newly developed electrically operated drawout single-pole breaker in the d-c breaker section provides high-speed feeder protection. It is particularly applicable where paralleled units in heavy duty service produce large fault currents incapable of being handled by conventional breakers.

The general purpose rectifiers employ direct air cooling, with recirculating air cooling as an alternate feature, a-c air circuit breakers for overcurrent protection, high-speed current limiting fuses in each paralleled path of each phase to protect the individual silicon diodes, while an a-c undervoltage relay prevents cell overloading from single-phase operation on the incoming feeder.

Requiring little maintenance, Allis-Chalmers silicon rectifiers have 95 to 96 per cent efficiency between 25 per cent and 100 per cent load. Their operation is quiet with fully visible instruments and no attendant is required.

From first heat to heat treat . . .

LOFTUS

designs and builds them better

International Harvester Co., West Pullman Works

COVER TYPE
ANNEALING FURNACES

DIRECT-FIRED SINGLE-STACK
Generally Recommended
for
Greater Productivity per Investment Dollar
and
Flexibility with Economy

LOFTUS
Engineering Corporation
1 Gateway Center, Pittsburgh, Pa.

57.12.4

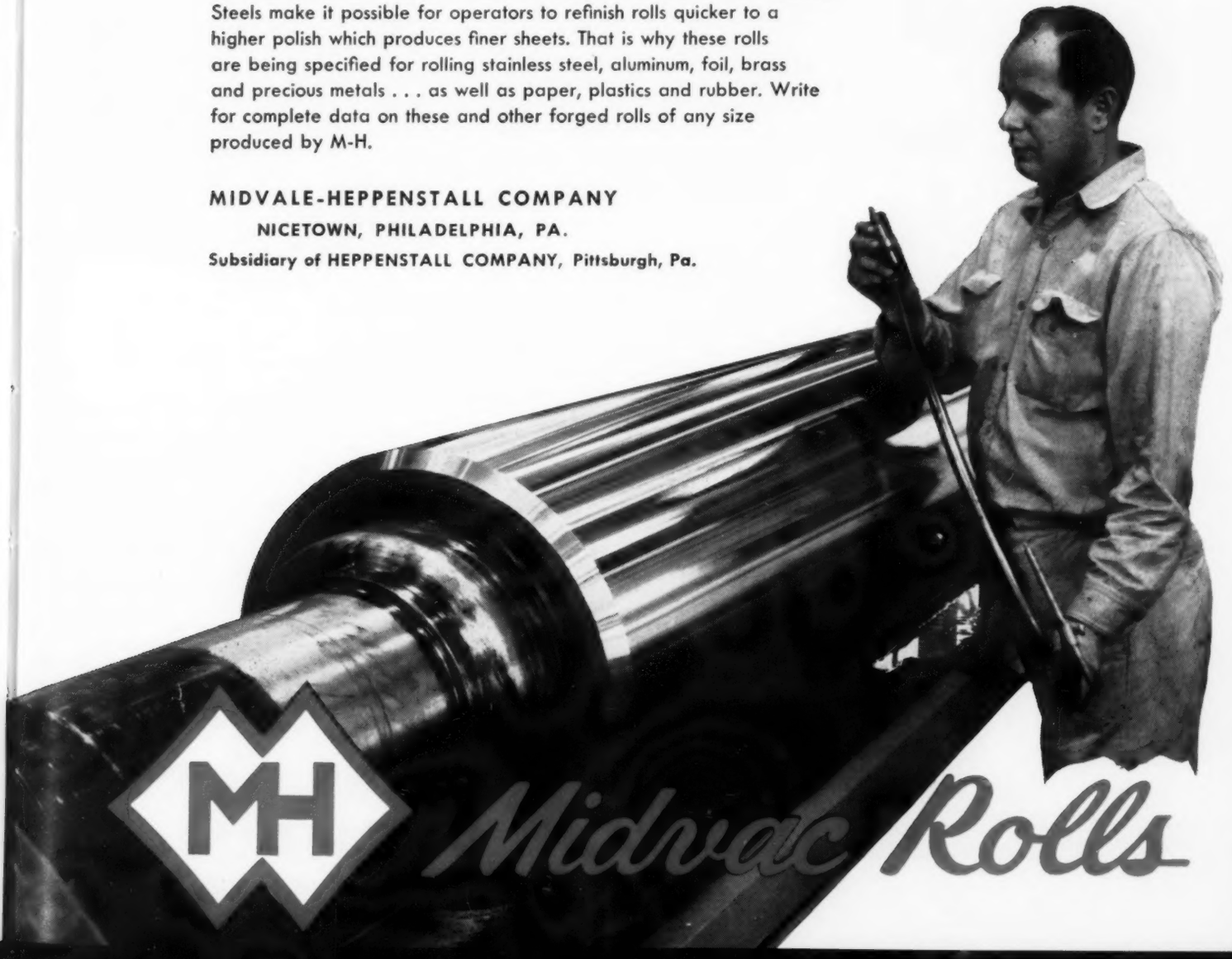
MIDVAC
Micro Lustre

VACUUM MELTED FINISHING ROLLS HAVE
CUT REGRINDING TIME IN HALF

The super uniformity of fine grain structure, maximum freedom of defects and non-metallic inclusions of Midvac Rolls have proved their value in mills from coast to coast. The Micro Lustre finish of these vacuum melted steel finishing rolls assures rolling surfaces free of imperfections . . . longer trouble-free service between grinds . . . and savings in refinishing time as much as 50%.

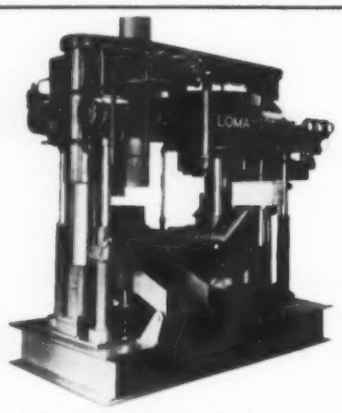
Midvac Rolls, made with consumable electrode vacuum melted Midvac Steels make it possible for operators to refinish rolls quicker to a higher polish which produces finer sheets. That is why these rolls are being specified for rolling stainless steel, aluminum, foil, brass and precious metals . . . as well as paper, plastics and rubber. Write for complete data on these and other forged rolls of any size produced by M-H.

MIDVALE-HEPPENSTALL COMPANY
NICETOWN, PHILADELPHIA, PA.
Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.

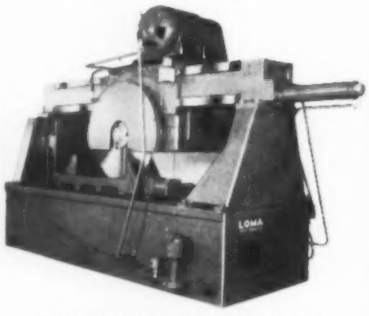


LOMA

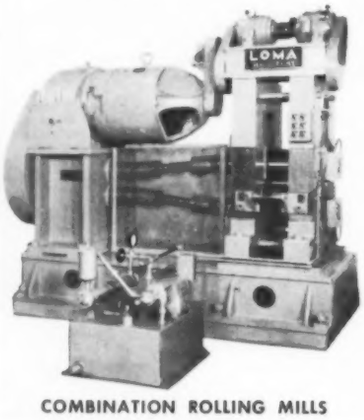
MAKES THEM ALL



CONTINUOUS CASTING MACHINES



CIRCULAR SAWING MACHINES



COMBINATION ROLLING MILLS

Our standard line of equipment includes:

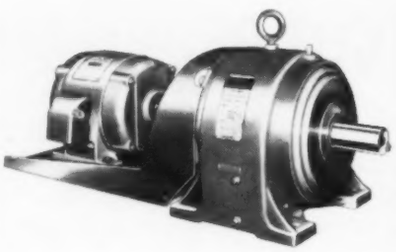
- Casting Machines and Molds
- Saws and Cut-off Machinery
- Hot and Cold Rolling Mills
- Rod and Tube Draw Benches
- Roller and Stretcher Levellers
- Air and Hydraulic Tube Testers

LOMA
MACHINE MFG. CO., INC.
114 East 32nd Street
New York 16, N. Y.

MOTOR MOUNTING

△ A line of standard gear reducers with mounting facilities to accommodate separate, coupling-connected standard NEMA motors of suitable horsepower, speed and electrical characteristics has been announced by The Lima Electric Motor Co., Inc.

These new gear reducers are available for horizontal foot mounted application, in either double or triple reduction units; double reduction units have a horse-



power range of one thru 125 hp, with reductions from 230 to 45 rpm. Triple reduction units range from one to 50 hp, with reductions from 37 to 7½ rpm.

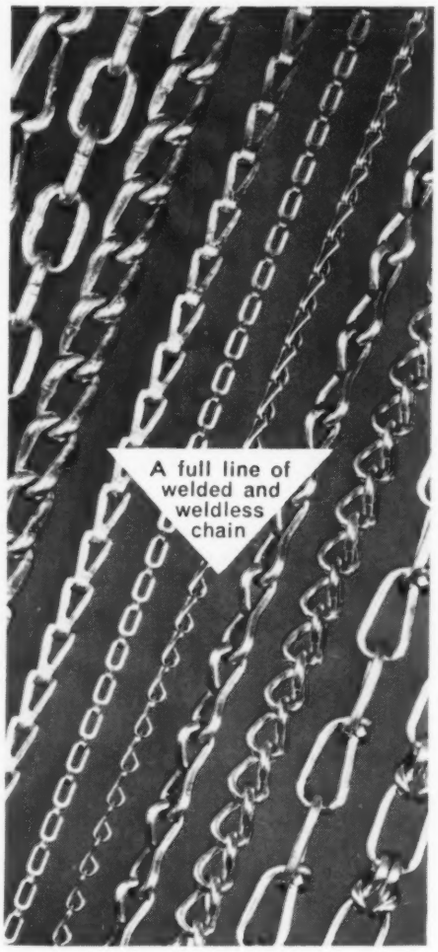
The gear reducers are equipped with Duti-Rated Lifetime Gearing to give many times more wear life than ordinary gears of same size and weight. In addition, the reducers are all equipped with an exclusive spline drive pinion which permits quick ratio changes anywhere—anytime—without complicated disassembly.

Motor mounting facility is so designed that motor mounting stresses cannot affect shaft alinement. Extra capacity bearings supported in a housing of great rigidity and strength make higher overhung load ratings possible.

PACKAGED ELBOW FANS

△ A new design of elbow fan for general ventilation and for use with such equipment as furnaces, dryers, ovens, kilns and plating and pickling tanks, has been introduced by L. J. Wing Mfg. Co. Standard units can handle clean or slightly contaminated air or fumes at normal or elevated temperatures. Special construction accommodates corrosive or explosive conditions. Installed in ductwork, the unit occupies only slightly more space than a standard elbow. A choice of three inlet connections is provided.

MUSCLES OF INDUSTRY!

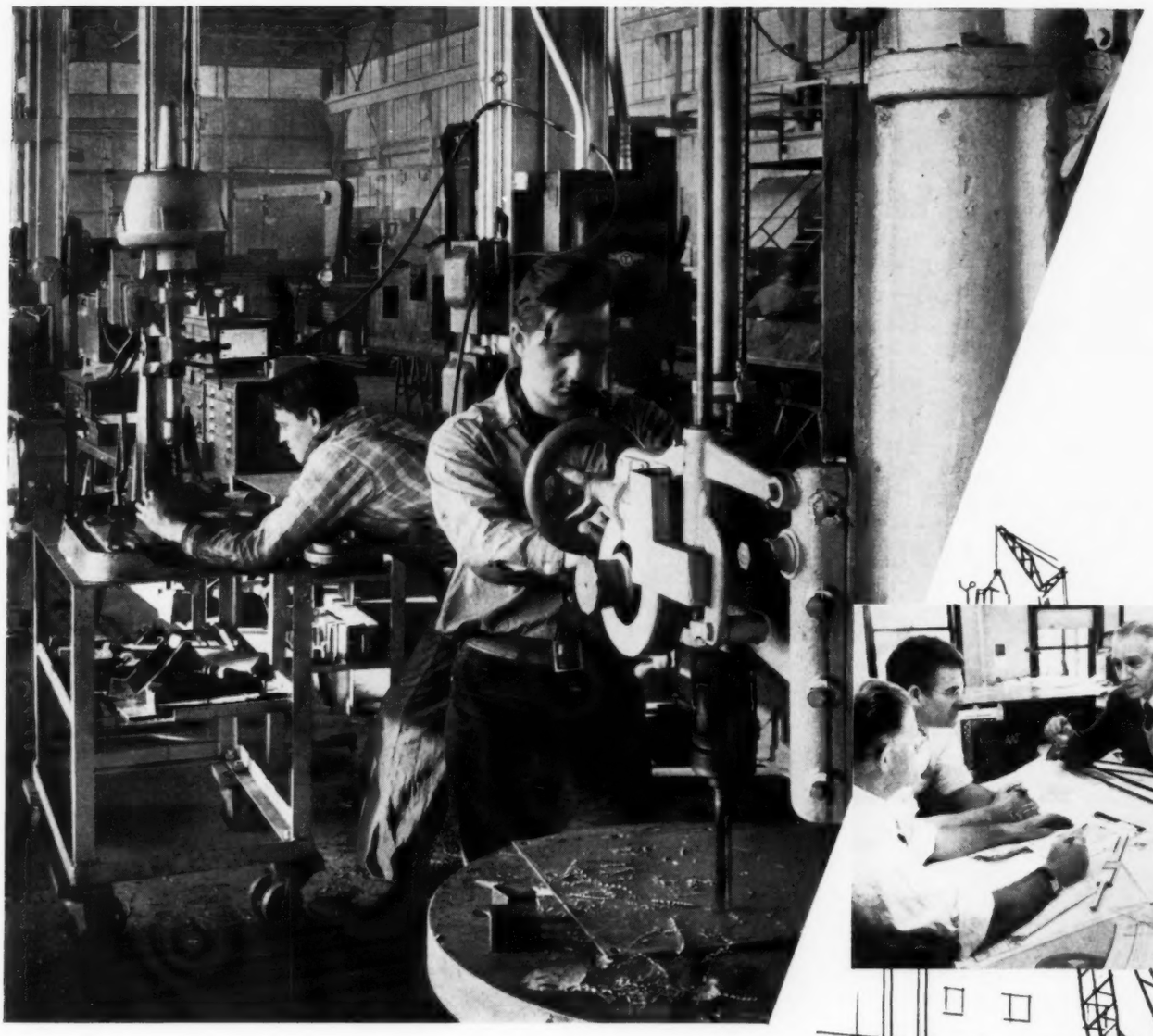


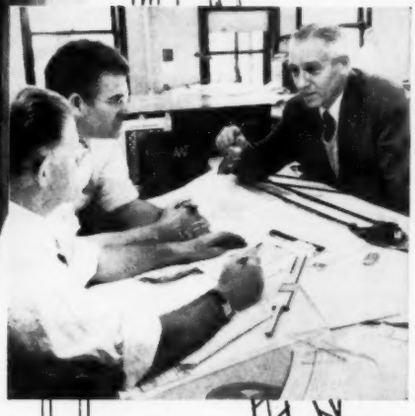
TM Chain is providing dependable muscles for industry every day. The tasks vary. Some call for tiny TM Jack Chain. Others demand the mighty TM Alloy Steel Chain for heavy overhead lifting. And, still others require one of the hundreds of additional types and sizes within Taylor's full line. Each does its job well. Quietly and unnoticed. Because, it is manufactured to meet Taylor's famed standards for fine quality.

Your chain costs could be higher than you think. Tell your distributor to make it "TM" the next time you buy. We promise you'll be time and money ahead if you do.

S.G. TAYLOR CHAIN CO., INC.
Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

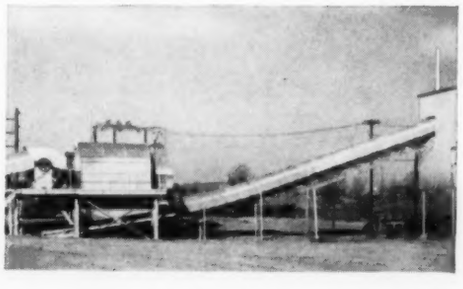
Taylor Made CHAIN SINCE 1873





Structural Steel and Platework Fabrication
for your Material Handling Plant
will be done in Roberts & Schaefer's shop

Every detail in the construction of a material handling plant must meet specific requirements. That's why Roberts & Schaefer handles structural steel and platework fabrication in its own modern shop. R&S does a complete job—design, engineering, fabrication, construction. You will find it worthwhile to use Roberts & Schaefer's specialized experience in material handling processing, distributing and storage systems. You will find here the background of knowledge and imagination to design and build a plant with the capacity, flexibility, performance and economy you want.



R&S

ENGINEERS & CONTRACTORS

ROBERTS & SCHAEFER *Company*

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CHEMICO VENTURI WASHERS... ELEVEN TROUBLE-FREE START-UPS ON BLAST FURNACES IN PAST 12 MONTHS

High operating efficiency and proven reliability are the two features which set Chemico Venturi Washers apart. In the last twelve months alone, Venturi equipment was installed in eleven blast furnaces with no start-up difficulties whatsoever. In addition, all eleven units exceeded their performance guarantees. Here are five reasons for this outstanding record:

- Standardized design permits efficient scale-up for any size furnace
- Wear-proof materials insure maintenance-free operation for *more* than furnace campaign
- Design includes complete flexibility to handle any blowing rate
- Simple maintenance-free water injection nozzles
- Newly developed high efficiency entrainment separator

Write today for further details from Chemico!

CHEMICO

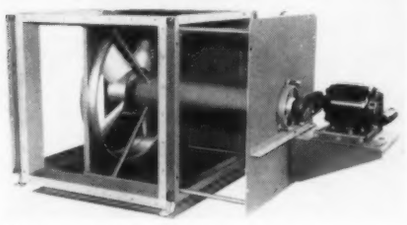
CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York

CHICAGO • DALLAS • HOUSTON • PORTLAND, ORE. • TORONTO • LONDON • PARIS • JOHANNESBURG • TOKYO

Wingfoil dynamically balanced fan wheels have true airfoil blade profiles for high efficiency with minimum turbulence, vibration and noise. Flat horsepower characteristics prevent motor overload even at full dampered shutoff.

An adjustable-pitch v-belt drive permits field adjustment of capacity to suit actual or changed conditions. For wider capacity variation, sheaves and even motors and fan wheels may be readily interchanged. A spring-loaded motor base minimizes need for realinement and automatically maintains proper belt tension for maximum belt and bearing life.

Motors, available in any type enclosure, are not exposed to hot or contaminated air or fumes. Bearings, located in an insulated shaft tube, are cooled with outside air and are



lifetime-lubricated. The entire motor and fan assembly can be removed without disturbing ductwork connections.

Wingflow elbow fans are available in five basic sizes with a wide choice of motors, for capacities from 600 to 32,000 cfm at static pressures to two in. or more. Standard fans can handle up to 750 F. Higher temperatures can be accommodated by admitting diluting cooling air.

SWITCH

△ Pennsylvania Transformer Division, McGraw-Edison Co. has announced the availability of an externally operated series-multiple switch on the company's "Pole Star" distribution transformers. This optional feature, which provides a choice of two high voltage ratings, is offered for transformers to be used on feeders that are expected to be raised to a higher voltage at some future date. Advantages include the relative ease with which the conversion to a higher voltage can be made, as well as elimination of the cost of changing transformers.

The dual voltage ratings include 2400 x 7200, 2400 x 7620, 4800 x 7620 and 4800 x 14,400 volts, with secondary ratings of 120/240 volts. Capacities range from 5 through 100 kva.

No special tools are required to turn the externally operated series-multiple switch. The cap of the switch serves as the only necessary tool.

A-C MOTORS

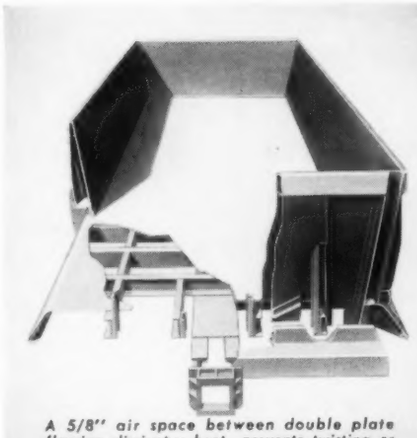
△ A new line of integral horsepower a-c motors has just been announced by Reliance Electric and Engineering Co.

Now available in sizes from one through 250 hp in protected (open), weatherproof, totally enclosed, corrosion-proof and explosion-proof enclosures, the new "Duty Master" motors may be specified in all standard speeds and voltages. Designs include polyphase, ball bearing, vertical and horizontal mounting arrangements with feet or footless, with NEMA C-face, D-flange or P-base brackets.

New single-phase motors, sleeve

MAGOR AIR DUMP CARS

FOR STEEL PLANT SERVICE



A 5/8" air space between double plate flooring dissipates heat, prevents twisting or distortion, protects underframe. Low alloy interiors insure greatest wear.

The new Magor Air Dump Car for steel plant service can cut your refuse disposal costs as much as 40%! Safe, swift, automatic dumping eliminates expensive labor and crane equipment. Low height and open type body means faster loading. Saves time, labor and haulage costs! Smooth interiors eliminate "dead load" returns!

The double-plate flooring shown here is just one of the many Magor design features that account for Magor's leadership in dump car production. Designed for the job — built to last, Magor Air Dump Cars cost less to buy — less to operate!

Savings effected by the new Magor Air Dump Cars will write off your entire dump car investment within a few years.

MAGOR

Write for your free folder describing America's number 1 air dump car, today!

MAGOR CAR CORPORATION

50 Church Street
New York 7, N.Y.

Where Severe Applications are Standard

WHIRLEX HEAVY DUTY FANS

TAKE OVER . . . Efficiently

This heavy duty WHIRLEX exhaust fan was custom designed for iron ore sintering machine. The unit is designed to carry hot gases at the rate of 200,000 CFM with 35 in. W.G. static pressure and is complete with scroll liner, cheek plate liner, blade wear pads, inlet louvre control dampers and removable section.

Additional facts and operating data on this and other WHIRLEX custom design fans are available at your request.

Fly Ash Arrestor
CORPORATION
208 North 1st. Street • Birmingham, Ala.

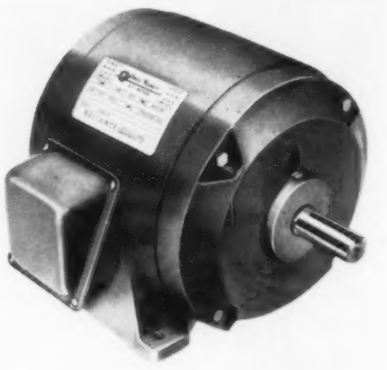
Dust Collectors • Induced Draft Fans
Forced Draft Fans • Exhaust Fans
Self Supporting Stacks • Duct Work

FLY ASH WHIRLEX ARRESTOR

bearing motors, resilient mount motors and larger rerated sizes in the design will be introduced in the coming months.

One of the principal features of the new Duty Master motors is the low inertia, fast accelerating rotor. Constructed of pressure-cast aluminum, the rotor is dynamically balanced to movement tolerances as precise as 0.0002 of an inch, to prolong bearing life and produce quiet operation. The low inertia rotor and increased accelerating torque combine with improved double-end ventilation to provide frequent stops without risk of injurious overheating.

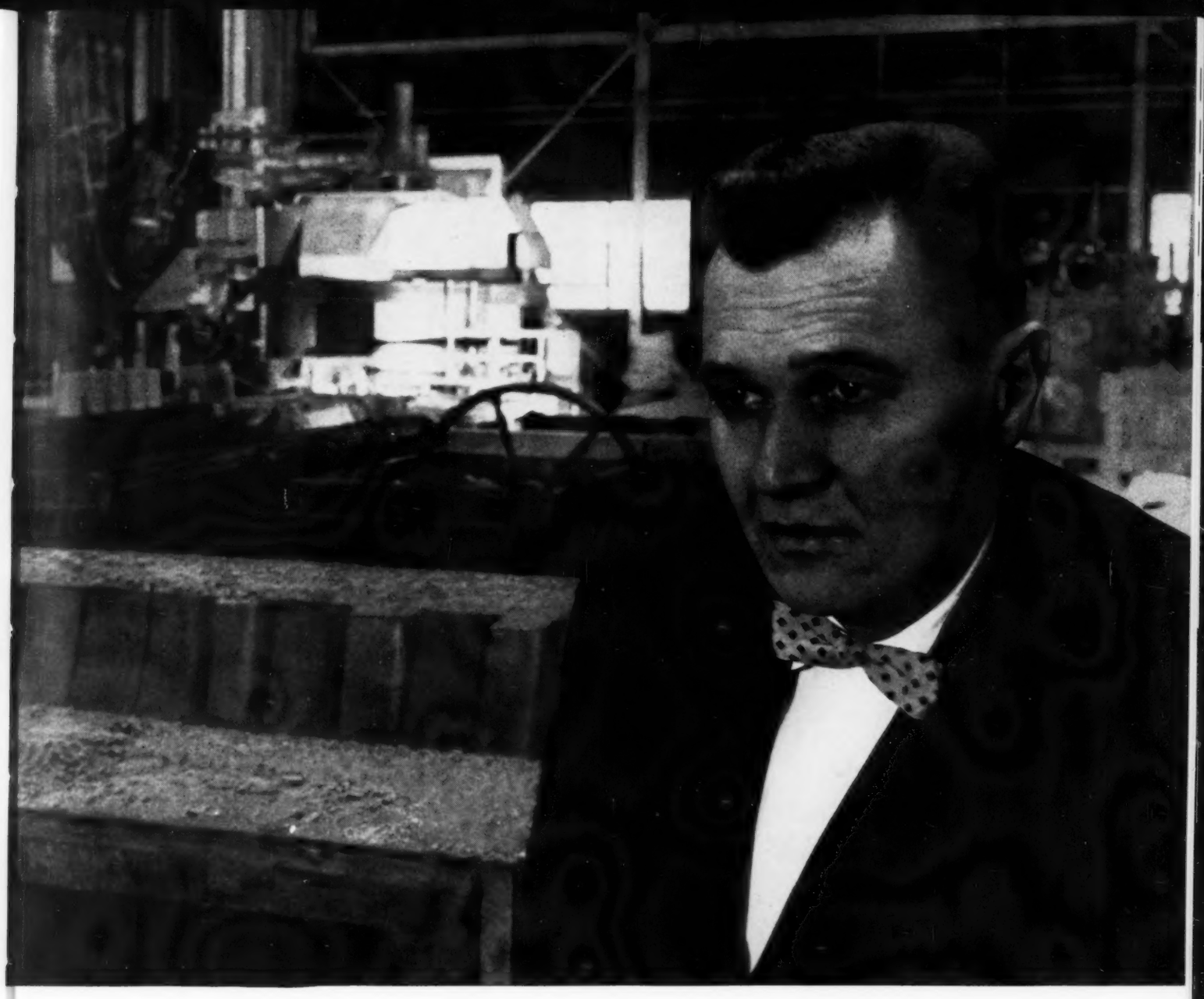
The rugged cast-iron frame of the new open motors protects from dripping or splashing liquids, and has a 40 C. temperature rise, continuous duty, with a 15 per cent service factor. The frame can be easily adapted to splashproof requirements when wall-mounted. The new



motors feature double-end ventilation on horizontal units above the 180 frame size, and through ventilation on all vertical or flange-mounted horizontal models through the NEMA 445U frame.

Exclusive Reliance Metermatic lubrication consists of double-shielded ball bearings and a special metering plate which automatically regulates the flow of just the right amount of grease to the bearings as needed. Automatic grease relief along the shaft eliminates overgreasing, while a special tight steel grease retainer on the inside of the bearings keeps dirt from entering the bearings and prevents grease from passing into the motor interior.

Slot cell insulation is laminated mylar-paper; the phase insulation is varnish glass, which is impervious to contaminating atmospheres. Molded, plasticized top and midsticks and vinyl glass sleeving on the



"If you have a rolling problem, call National,"

says John Patton, Assistant Manager—Roll Sales

"... we believe we can contribute to its solution. Our organizational backbone is 'men'—men, trained and experienced in metallurgy and foundry practice who take an individual interest in each problem and its solution ... just as they take an individual interest in the production of each roll that goes through our plant.

"For instance, every steel roll order is individually processed with careful planning and meticulous checking of each detail. Our wide range of furnace sizes permits pouring each order from an individual heat.

"Chilling of each mold is carefully calculated to insure deep penetration for maximum life and high resistance to firecrack and spalling.

"This same care is followed throughout production—through heat-treating, machining, testing, inspecting and shipping.

"So we repeat, 'If you have a rolling problem, call us. Let us help you solve it.'"

GENERAL STEEL CASTINGS

National Roll & Foundry Division

Avonmore (Westmoreland County) Pennsylvania

General Steel Castings Corporation: General Offices, Granite City, Ill.

Plants: Granite City, Ill.—Eddystone, Pa.—Avonmore, Pa.

leads complete the balanced insulation system. Preheated dry windings are repeatedly immersed in thermosetting varnish and baked, then coated with a special red finishing enamel for complete protection against acid, alkali, water, oil and most adverse environmental contaminants. Coil heads are designed to tuck snugly within the protective cover of the motor frame, to prevent damage during assembly or disassembly.

The large conduit box is diagonally split to expose the leads for convenient connection. Positive, permanent lead markings of each wire provide instant identification of leads to minimize connection time. The stainless steel nameplate provides room for additional customer data, if required. It can not corrode, and comes clean with the wipe of a rag even after long exposure to corrosive atmospheres.

BALLASTS

△ Type EMB explosion-proof ballasts have been designed for use with Crouse-Hinds Co. EV Series (explosion-proof) and DL Series (dust-ignition-proof) Condulet lighting fixtures for hazardous locations. Of the auto transformer type, these high power factor ballasts operated on 60 cycles alternating current, with triple tap primaries that closely match line voltage to ensure maximum lamp efficiency and lumen output. Because they are explosion-proof and dust-ignition-proof, they may be installed in the hazardous area, with the lighting fixtures.

The new ballasts are supplied for a single 250-watt lamp, or one or two 400-watt lamps. In two-lamp applications, one fixture can be supported directly from the junction Condulet; the second fixture can be supported from a fixture hanger Condulet.

Two-lamp ballasts provide the more economical installation because several circuits feeding the fixtures can be carried through the 1¼ in. conduits. In this way, separate fixtures may be supported from branch conduits entering the side hubs of the junction Condulet. Leads are factory-sealed; adjustable straps and a union support the ballast and facilitate assembly.

DATA PROCESSING UNIT

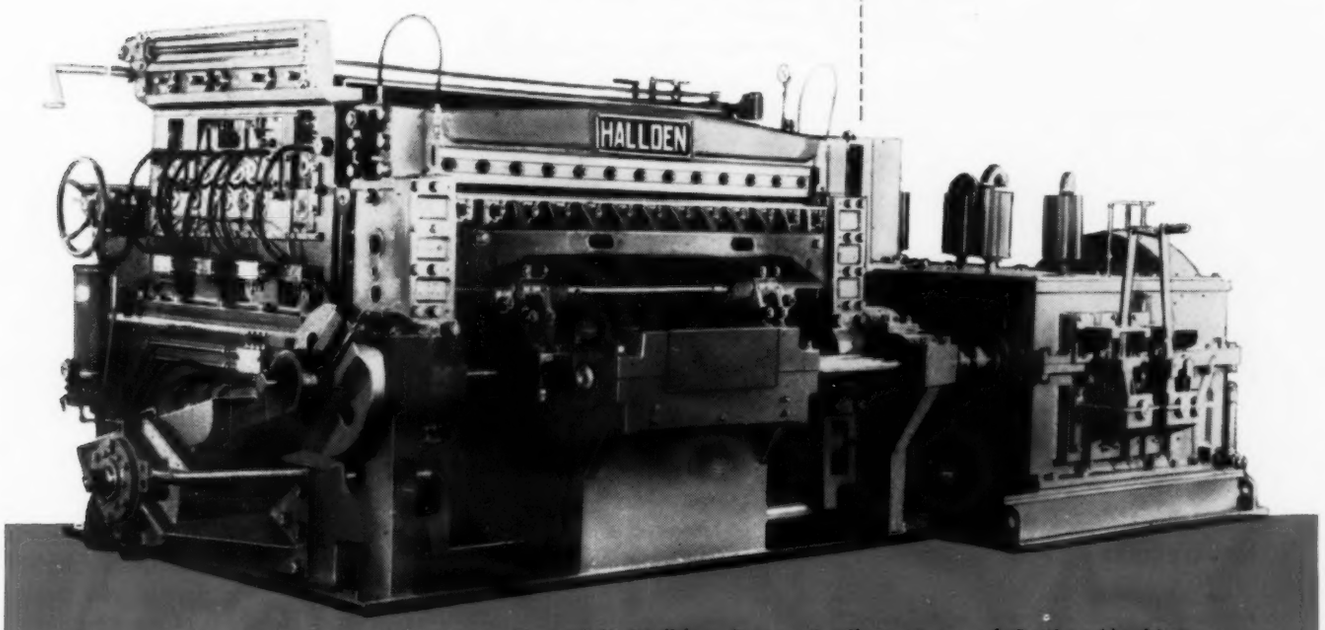
△ A completely new system for processing industrial data, featuring plug-in units to perform a wide variety of additional functions, has been introduced by the Kybernetes Division of Hagan Chemicals & Controls, Inc.

The Kybernetes Series 2000 data processing system utilizes four basic

Stamco

announces

the addition of HALLDEN equipment to their complete line of steel mill equipment. Hallden and Stamco, teamed together...available from one source for complete integrated planning.



Type 541 Hallden Automatic Flattening and Cutting Machine

Stamco, Inc.

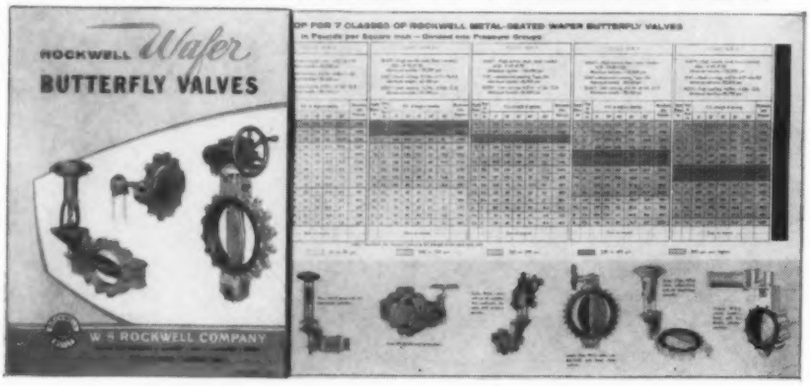
NEW BREMEN, OHIO, U.S.A.

ADVANCED ENGINEERING • SUPERIOR CRAFTSMANSHIP

Slitting and Coiling Lines • Cut-To-Length Lines • Flying Shear Lines • Power Squaring Shears • Automatic Resquaring • Corrugating • Culvert • Steel Mill Equipment

NOW! SELECTION MADE EASY

OF THE "WAFER" BUTTERFLY VALVE YOU NEED FOR REQUIRED RANGE OF PRESSURE DROP



This new Bulletin No. 583 gives all the facts to help you select just the size and construction of valve for your air, gas or liquid lines. Illustrations—charts—tables are arranged in a practical, easy-to-use manner. Write for your copy.

ROCKWELL SINCE 1888 BUILT

W. S. ROCKWELL COMPANY

Valves—Butterfly · Slide · Diaphragm · Special

2429 ELIOT STREET • FAIRFIELD, CONN.

FOR UNIFORM HEATING AND EFFICIENT AGITATION SPECIFY

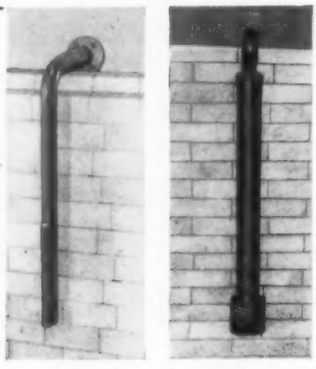
HEIL of Cleveland

Steam Jet Agitators

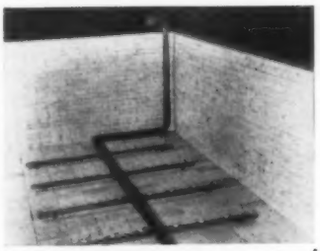
they shorten the pickling cycle and increase tonnage output.

The standard for low-cost, continuous pickling of strip, or the batch pickling of sheets, coiled rods, wire and other products. Hundreds of successful installations.

Use of rugged, durable, lead extrusions, highly resistant to mechanical and thermal shock, assures long, maintenance-free operation. Heil exclusive Nocordal impervious graphite nozzles imbedded securely in the lead, at properly spaced intervals, provide efficient heating, uniform agitation, and prevents the steam from eroding the outlet.



Heil Steam Jets for Continuous Pickling Applications



Heil "E-4" Steam Jet Agitator System for Batch Pickling

Write for the Heil fully descriptive bulletins. They give complete details and specifications.

CHEMICAL-PROOF LININGS · TANKS HEATERS PLASTICS

HEIL PROCESS EQUIPMENT CORPORATION

12924 Elmwood Ave. Cleveland 11, Ohio

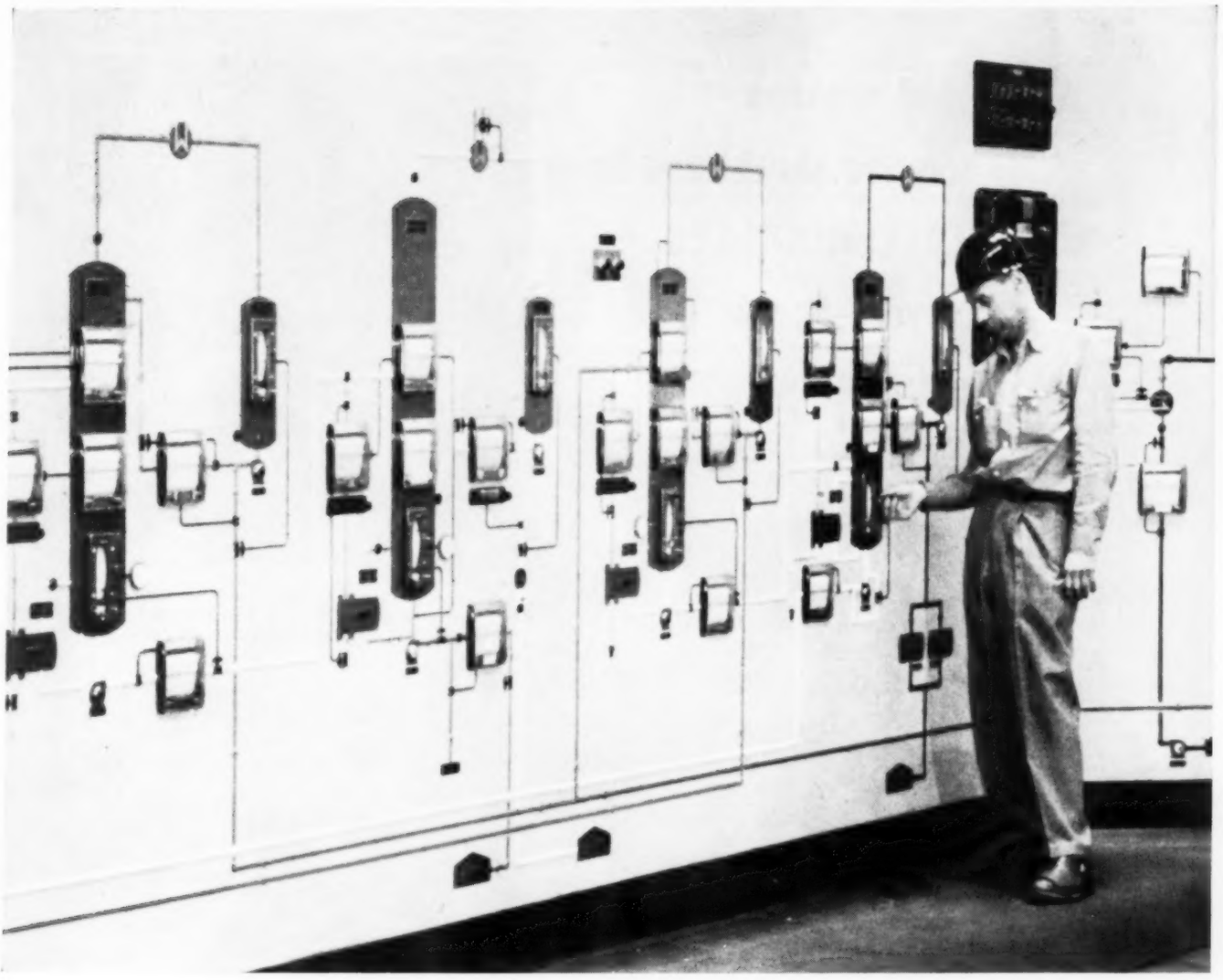
modular chassis, plug-in housings, and a unique pinboard arrangement for function programming. Solid state components have been incorporated in the new system to provide added reliability.

The basic logging unit of the Series 2000, which records process data on a log sheet or other output device, can be expanded to provide for the scanning of an increased number of points and to perform a broad range of additional operations. These include scanning for off-normal conditions, printed or visual trend of selected variables, computing and integrating, automatic programming and optimum setting of control. All added functions can be carried on without interruption of the basic scanning operation.

Pinboard programming adds flexibility to the new system. By the insertion of pins into a prewired board, the desired operational characteristics can be selected for full-scale ranging, zero suppression, trend logging, alarm set points, and function programming of such items as linearization, square root extraction, amplifier gain, computations and the number of digits logged. This permits field alteration of system programming where desirable.

The use of converters in the new system provides complete freedom of choice in the selection of process variable transducers, whether a-c, d-c, or digital types. Utilizing specially developed techniques, the Kybernetes ac-dc converter receives the a-c signal from the transducer and produces a d-c output with a conversion accuracy within 0.05 per cent.

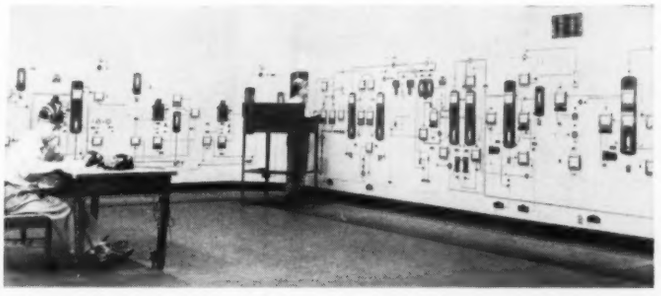
Installation and maintenance of the Series 2000 are simplified by the addition of a number of new design features. Isolation of a-c circulating currents from the data system is achieved through sequential chopping of the analog voltages onto a capacitor. An all-electronic, self-balancing d-c amplifier is utilized to eliminate 60-cycle ripple and high-frequency noise transients. Self-checking circuits provide immediate warning and location of trouble spots. Simplified design of basic chassis permits replacement of defective unit, without necessity of immediate electrical analysis and repair.



Foxboro Consotrols* "easy on maintenance" at U. S. Steel's Gary Works

Foxboro Consotrol Instruments have been in service 5 years at U. S. Steel's Gary Works, yet only a few have ever needed calibration. In fact, Gary Works reports that many of the Foxboro M/58 Controllers have never even had their covers off.

Low maintenance is just part of the Foxboro Consotrol story. Sustained high accuracy, precise repeatability, a full range of control functions — you get them all when you specify Consotrol instrumentation. Get full details in Bulletin 13-18, or call your nearby Foxboro field engineer. **The Foxboro Company, 589 Neponset Ave., Foxboro, Mass.**



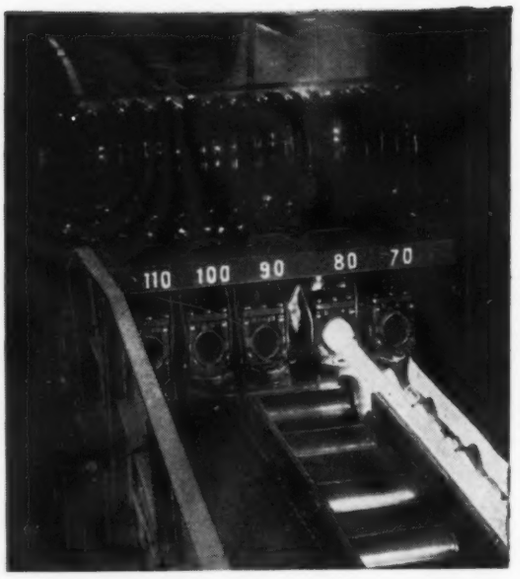
83 foot graphic control panel for Gary Works Light Tar Distillation Plant was built by Foxboro in 1954. 250 Consotrol instruments record and control all temperature, pressure, flow and liquid level variables. *Consulting Engineers:* United Engineers and Constructors, Inc., Philadelphia.

*Reg. U.S. Pat. Off.

FOXBORO

REG. U.S. PAT. OFF.

8 good reasons why you should use these ROLLER GUIDES in your bar or wire rod mill



Nos. 125 and 155 roller guides fitted in a 27 1/2 in. (700 mm.) diameter, three-high stand for rolling 2 3/4, 3 3/16, 3 9/16, 4, 4 3/8 and 4 7/8 in. (70, 80, 90, 100, 110 and 124 mm.).

1 The entry friction guides are rigidly clamped into the guide box. They are intended to lead the oval to the groove in the roller, to protect the rollers against overloading, and to straighten bent rods.
The groove in the entry guides is made about 1/8" wider than the oval.

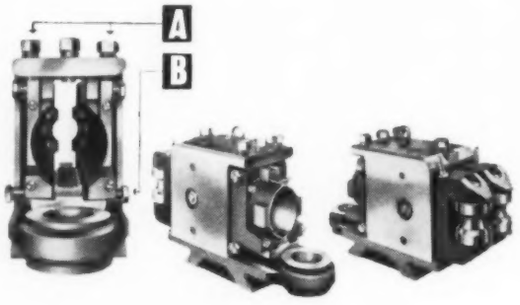
2 The rollers are mounted on leaf springs, which can be adjusted by means of the screws "B", and hold the oval steadily even if there should be some slight variation in the thickness of the oval.

3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be thick, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.



7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

8 The roller guide may be used not only for leader and drawing oval passes but also for edging flats as well as for rolling squares, hexagons, octagons and various other sections, for instance in reduction passes for hexagon. It is suitable for all types of rolling mill. An important advantage is that the roller guide enables repeaters to be used in rolling plump leader-ovals.

PS *Practically speaking, every bar and wire rod mill in Scandinavia uses roller guides of our design.*

MORGÅRDSHAMMAR

MORGÅRDSHAMMARS MEK VERKSTADS AB • MORGÅRDSHAMMAR • SWEDEN

SOLE AGENT FOR THE US:
K.W. Atwater Engineering, Inc.
401-03 Butler Street
Pittsburgh 23, P.A.

Telegrams: Morgårdshammar, Ludvika, Sweden

CLOSED CIRCUIT TV

△ Motorola, Inc., has introduced a line of closed circuit television cameras and monitors to be available for sale during the last quarter of the year. It marks the Chicago firm's entrance into the industrial and educational television field.

The basic Motorola general purpose camera is a high quality, highly sensitive and stable instrument, providing 550–600 lines horizontal resolution. Weighing 12 lb and measuring 5½ x 7 x 11 in., the camera puts out a one volt video signal into a 75 ohm coaxial cable. The camera uses a standard 16 mm C lens mount and can accommodate a remote control four lens turret. Such remotely controlled functions as pan and tilt, iris control, focus and zoom lens can also be added to the camera. The units provide (1) either automatic light compensation, or, manually controlled compensation; (2) either random interlace, or, locked interlace. The automatic models adjust by themselves for variations as much as 200 to one in light levels at the televised scene. This eliminates the need to make camera adjustments as lighting conditions change. On the automatic camera, an on-off switch is the only operating control.

The industrial monitor has a 14-in. screen. Ruggedly constructed, it provides high brightness, 600 line resolution and excellent stability.

Included in the new Motorola line are complete selections of mounting, optical and distribution accessories to meet all application requirements. As in its other communication products lines, Motorola will provide a complete system design, engineering and maintenance service along with its equipment.

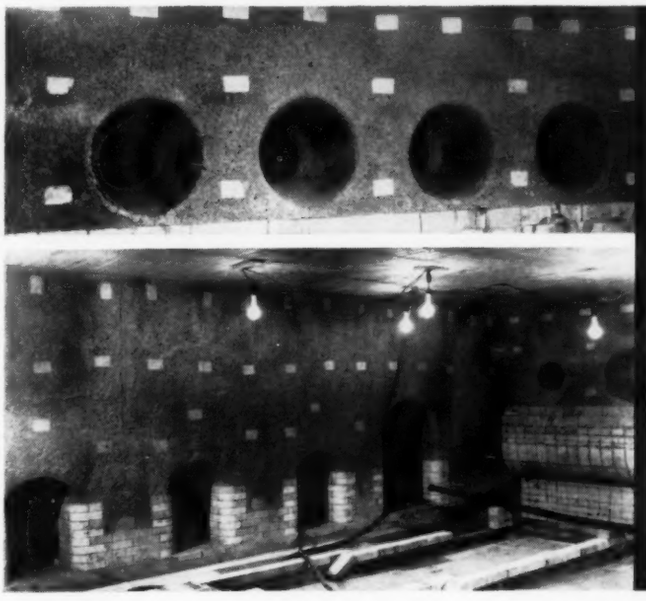
MECHANICAL RAKE

△ Introduction of an improved type of mechanical rake for cleaning debris from trash racks or screens in front of gates where water is required in large volume, as encountered in pumping, processing and sewage disposal installations, is announced by Frank W. Stuker and Associates. Patented features of the Stuker rake are the culmination of long engineering experience in building tainter gates and sluice gates. The announcement follows outstanding field performance of the rakes in applications on large (3400 cfs) units of hydroelectric power intakes.

The rake is self-guiding, self-clearing and self-dumping to provide thorough removal of trash ranging from light debris to heavy water logged materials. They safeguard gates, valves, pumps, turbines and other equipment to reduce interruptions to service and costly repairs. They can be made to start and operate automatically on signal from remote control or differential water level.

Electrically driven mechanism handles a complete range of depths with low power consumption. Easy one-man operation makes it possible for the rake to travel across the face width of rack bars extending across the forebay.

USE THE ENGINEERING MART



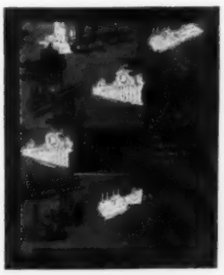
PLIBRICO "Super" and PLIBRICO "Super F" plastics form a continuous, fully-anchored monolithic lining for the side walls and burner walls, with smooth contours around the door arches and burner cones, in this Salem-Brosius slab reheating furnace.

Plibrico plastic refractories selected at Inland Steel Co. for 130 tons/hr slab reheating furnace

Properties of Plibrico "Super" and Plibrico "Super F" plastic refractories are geared to the demands of this 99′ triple-fired slab reheating furnace placed in service in 1958 at Inland's 76″ mill. Capable of withstanding severe conditions, Plibrico "Super" lines the preheat zone, while Plibrico "Super F" lines the high heat and soaking zones.

Less maintenance—longer service life assured . . . formulated specifically for tough assignments, Plibrico "Super F" is highly resistant to stresses, vibration, mechanical and thermal shock. It is exceptionally stable, and with its low porosity resists destructive penetration of otherwise harmful combustion by-products.

For furnace linings that cost less and last longer, call your local Plibrico distributor-engineer . . . WRITE FOR CATALOG 69 covering steel mill, industrial and foundry applications



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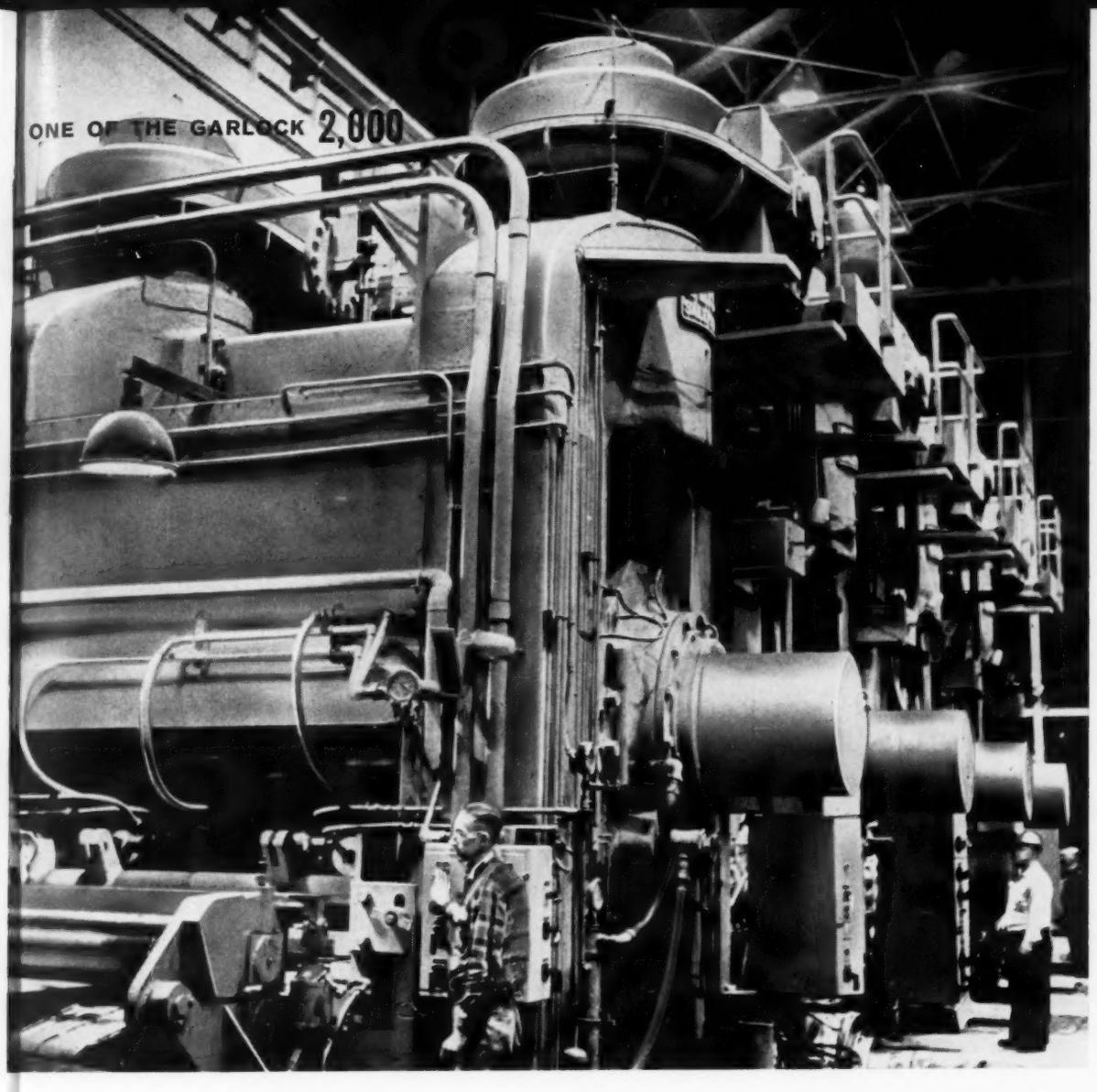

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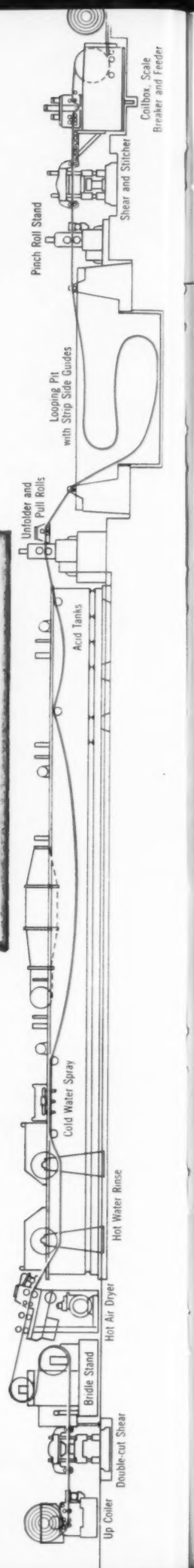

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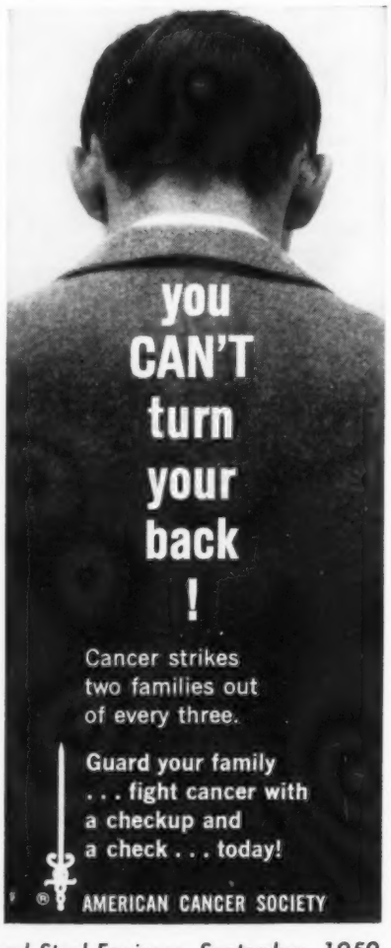

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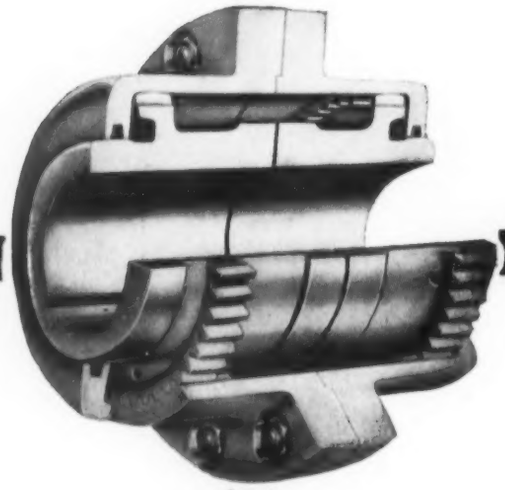

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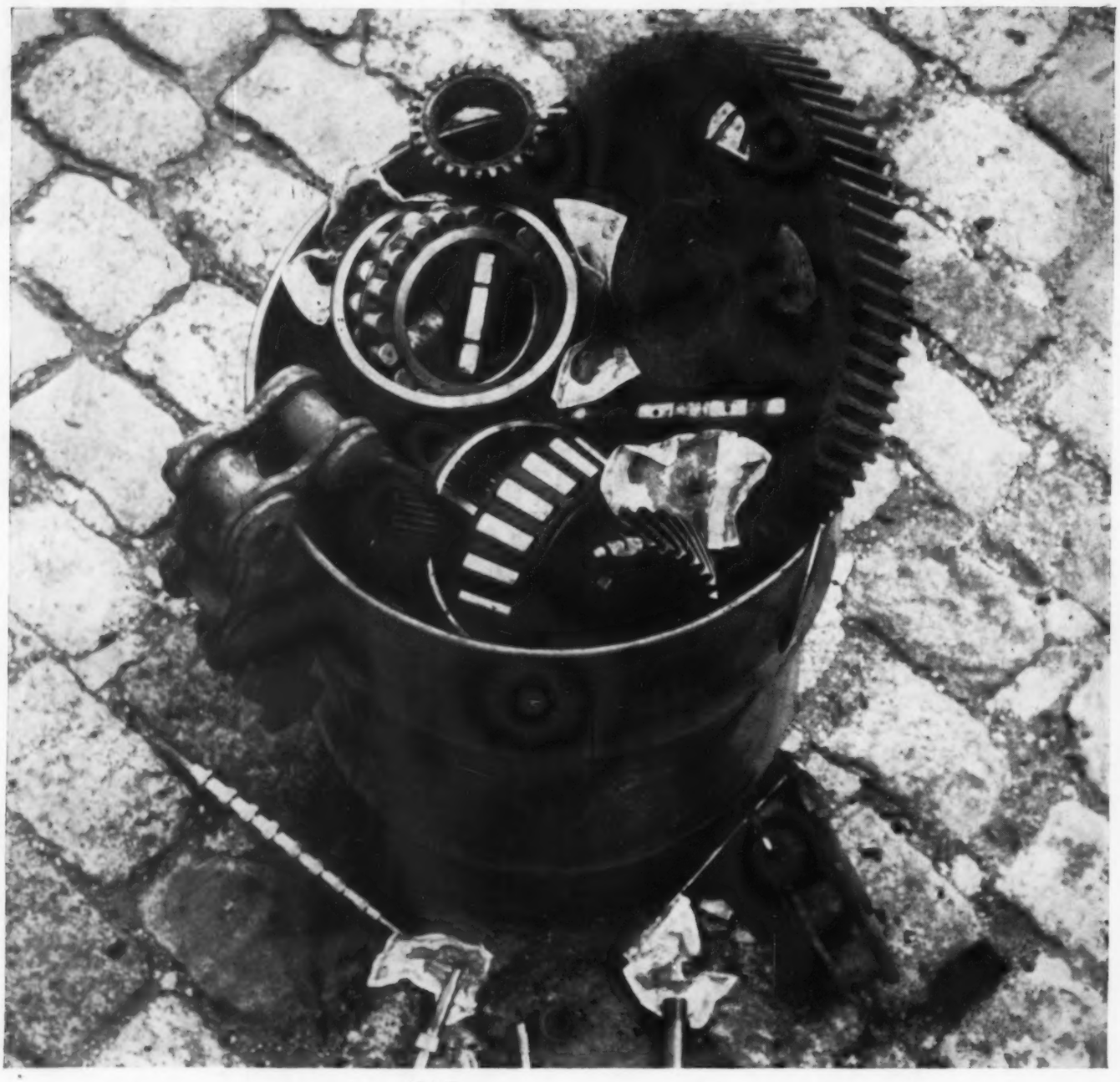

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